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14. ABSTRACT
This collaborative research proposal was submitted to program announcement W81XWH-09-DMRDP-ARATDA at the request of the Command Surgeon of the United States Army Special Operations Command (USASOC) to scientifically develop THOR3's injury prevention and human performance program. This research will conduct the first three phases of a four phase research objective to ultimately improve physical readiness and mitigate unintentional musculoskeletal injuries.

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Introduction

Unintentional musculoskeletal injuries limit tactical readiness, shorten the active duty life cycle, and diminish the quality of life of the soldier after military service. Many of these injuries are preventable or their severity mitigated through implementation of demand-specific physical training for injury prevention and performance optimization developed through scientific research. At the request of the Command Surgeon from the United States Army Special Operations Command (USASOC), this research proposal will support development of USASOC's Tactical Human Optimization, Rapid Rehabilitation, and Reconditioning (THOR3) program to identify the priorities necessary for enhancement and change in the current physical training program. Consistent with our injury prevention and performance optimization model previously developed from over 20 years of research with elite athletes and six years of collective research with Naval Special Warfare Group 2 (NSWG2) and the 101st Airborne (Air Assault), this proposal will address the cause and prevention of musculoskeletal injury and detriments to optimal performance by identifying suboptimal biomechanical, musculoskeletal, physiological, and nutritional characteristics that are task and demand-specific to the Special Forces soldier.

Body

Project Overview

This collaborative research proposal was modeled after our research with Naval Special Warfare and was submitted to program announcement W81XWH-09-DMRDP-ARATDA at the request of the Command Surgeon of the United States Army Special Operations Command (USASOC) to support development of USASOC's Tactical Human Optimization, Rapid Rehabilitation, and Reconditioning (THOR3) program and identify the priorities necessary for improvement and change in their current physical training program. The overall objective of our four phase research initiative is to provide the scientific arm by which USASOC will refine its THOR3 program. It is our intent the research will result in a validated THOR3 program that reduces unintentional musculoskeletal injury and improves physical and tactical readiness. The current research proposal under this award will test the first three phases of research and is hypothesized to result in identified injury characteristics and risk factors of the USASOC Operator and a validated THOR3 program which alters injury risk characteristics. The proposed research study addresses the project/tasks as outlined in Funding Opportunity Number: W81XWH-09-DMRDP-ARATDA (Operational Health and Performance- Fundamental Mechanisms of Training and Operational Injury). The fourth and final phase of research will test the THOR3 program to reduce unintentional musculoskeletal injury (not part of the current submission- to be submitted under a separate SOW).

The current proposal will include activities performed at the USASOC/University of Pittsburgh Human Performance Research Laboratory at Fort Bragg, NC and protocol development, research monitoring, verification of data integrity, report preparation, and data processing/interpretation completed at the Neuromuscular Research Laboratory, University of Pittsburgh, Pittsburgh, PA.

Specific Aims:

Phase 1 Aim 1: To perform an epidemiological analysis of the unintentional musculoskeletal injuries sustained by USASOC Operators

Methods: A descriptive epidemiological design will be used to analyze retrospective unintentional musculoskeletal injury data from the previous five years of operation. Injury data will be queried from the Armed Forces Health Surveillance Center (AFHSC) and medical records maintained by the medical and physical therapy personnel of USASOC. Injury data from the AFHSC will be queried based on ICD-9 codes 710-739 and 800-899 and when available supplemented with ICD-9 E codes (external causes of injury codes). Individual encounters will be reported based on the ICD-9/ICD-9 E codes for a given anatomic region, limb, and identified with the corresponding time category for date range. Encounters will be defined as one injury per anatomic region every 60 days. Demographic data including age, height, and weight will be reported. Injury data queried by the medical and physical therapy personnel of USASOC will provide a summary of injury mechanisms to supplement the ICD-9 E codes. Phase 1 Aim 1 research activities will be performed in Y1Q1-Y1Q2.

Deliverables: The data from this aim will measure the frequency of unintentional musculoskeletal injury sustained by the USASOC Operator. The data from this aim will also be used to modify laboratory testing in Phase 2 should group-specific injury patterns be identified. This specific aim will also be used to identify the necessary procedures for injury data collection in Phase 4. The data from this aim will be submitted for publication with authors from the University of Pittsburgh and Command Surgeon of the US Army Special Operations Command. The authors submit the paper with the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the peer-reviewed journal. All named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and all must have critically reviewed its content and have approved the final version submitted for publication.

Phase 1 Aim 2: To describe the tactical and physical tasks which result in the greatest proportion of unintentional musculoskeletal injuries

Methods: Based on the injury data and in consultation with USASOC personnel (training, medical, human performance, and Team Sergeants) representative tactical tasks will be identified to quantify segmental accelerations of the spine and lower extremity and describe the biomechanical and musculoskeletal demands. Collaboration with USASOC personnel will identify the mission-specific tasks which result in unintentional musculoskeletal injury. Data will be examined on a sample of Operators based on the identified tactical tasks. Injury data from the medical and physical therapy personnel of USASOC will support identification of appropriate tasks which result in significant injury to the USASOC Operator.

Deliverables: The data from this aim will be used to supplement the injury data identified in Phase 1 Aim 1 to further describe the injuries sustained by the USASOC Operators. The data from this aim will also be used to develop functional laboratory tests to replicate USASOC-specific demands. This specific aim will also be used to identify the necessary procedures for injury data collection in Phase 4. The data from this aim will be submitted for publication with authors from the University of Pittsburgh and Command Surgeon of the US Army Special Operations Command. The authors submit the paper with the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the peer-reviewed journal. All named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and all must have critically reviewed its content and have approved the final version submitted for publication.

Phase 2 Aim 1: To prospectively identify biomechanical, musculoskeletal, physiological, and nutritional risk factors for injury in USASOC Operators

Methods: A prospective analysis of risk factors for unintentional musculoskeletal injury will be conducted based on biomechanical, musculoskeletal, and physiological data collection. The biomechanical characteristics of the knee, shoulder, and torso will be analyzed using a 3D motion analysis and force plate system. Isokinetic and isometric strength of the neck, torso, shoulder, knee, hip, and ankle will be measured with an isokinetic device or handheld dynamometer. Range of motion of the neck, torso, shoulder, knee, hip, and ankle will be assessed with goniometers. Static and dynamic balance will be assessed with force plates and a stability system. Body composition will be measured with air displacement plethysmography. Aerobic capacity and lactate threshold will be measured with a metabolic system and lactate analyzer. Anaerobic power and capacity will be measured with an electromagnetic ergometer. Nutrition data will include a 24 hour recall and nutrition history. The 24 hour recall will be assessed with the ASA 24 to assess food types and quantities. A nutrition history will assess supplement intake, overall habits, and fueling and hydration habits before, during, and after physical training. These data will be analyzed in relation to prospectively collected unintentional musculoskeletal injury data (self-reported, AFHSC, medical and physical therapist-reported). Injury data will be captured for the 12 month period following laboratory testing. It is our intent that utilizing several sources of injury data will improve the validity of the data query for completeness without relying solely on an individual source where potential injuries, mechanisms, or tasks may be empty. Based on a cumulative incidence of 13-22% injured for given musculoskeletal injuries up to 480 subjects will be required to identify biomechanical, musculoskeletal, and physiological contributors to injury with a power of 0.80 and statistical power of $p < 0.05$. Phase 2 Aim 1 research activities will be performed Y1Q3-Y3Q4.

Deliverables: The data from this phase will prospectively identify risk factors for unintentional musculoskeletal injury. The data may be used as a screening mechanism to identify individual Operators who may be at a greater risk of injury due to established risk factors. This data will be provided to USASOC's THOR3 human performance personnel to integrate into current physical training for validation in Phase 3. Specific recommendations will be made for changes in the THOR3 program based upon the data obtained. The data from this aim are the foundation by which the THOR3 program will be implemented in Phase 4. The data from this aim will be submitted for publication with authors from the University of Pittsburgh and Command Surgeon of the US Army Special Operations Command. The authors submit the paper with the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the peer-reviewed journal. All named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and all must have critically reviewed its content and have approved the final version submitted for publication.

Phase 2 Aim 2: To determine the relationship between previous history of unintentional musculoskeletal injury and biomechanical, musculoskeletal, physiological, and tactical characteristics

Methods: Biomechanical, musculoskeletal, physiological data captured during Phase 2 Aim 1 and tactical characteristics will be evaluated to determine the relationship with retrospective unintentional musculoskeletal injury history. Unintentional musculoskeletal injury data will be captured with a self-reported questionnaire to identify the frequency of injury, mechanisms, tasks, and other contributing factors of the injury event. Phase 2 Aim 2 research activities will be performed Y1Q3-Y3Q4.

Deliverables: The data from this aim will identify potential residual deficits as a function of previous injury and impact as confounding factors to laboratory testing. The data from this aim are the foundation by which the THOR3 program will be implemented in Phase 4. The data from this aim will be submitted for publication with authors from the University of Pittsburgh and Command Surgeon of the US Army Special Operations Command. The authors submit the paper with the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the peer-reviewed journal. All named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and all must have critically reviewed its content and have approved the final version submitted for publication.

Phase 2 Aim 3: To identify suboptimal biomechanical, musculoskeletal, physiological, tactical, and nutritional characteristics for physical readiness in the USASOC Operator

Methods: Biomechanical, musculoskeletal, physiological, and tactical readiness data captured in Phase 2 Aim 2 will be analyzed for suboptimal contributors to physical readiness. Biomechanical, musculoskeletal, physiological, and nutrition data will be compared to data sets of athletes, evidenced-based practice, and tactical athletes when appropriate. These data sets will include athletes tested at the Neuromuscular Research Laboratory at the University of Pittsburgh, literature demonstrating risk factors for unintentional musculoskeletal injury, characteristics of suboptimal performance, and data from tactical athletes from other University of Pittsburgh US Special Operations Command research projects. This comprehensive approach will be utilized to identify specific suboptimal characteristics relative to performance optimization without relying solely on an individual source for comparison. An additional USASOC tactical athlete cohort from the current study will be included once sufficient data are obtained to primarily test the tactical readiness characteristics. Phase 2 Aim 3 research activities will be performed Y1Q3-Y3Q1.

Deliverables: The data from this aim will establish suboptimal physical readiness characteristics based on comparison to athlete, evidence-based, and tactical athlete optimization data sets. The data will be provided to USASOC's THOR3 human performance personnel to integrate into current physical training for testing in Phase 3 and Phase 4 (not part of the current submission- to be submitted under a separate SOW). The nutrition data will be provided to the THOR3 registered dietitian for immediate implementation into clinical practice and not further tested with Phase 3 or 4. The data from this aim will be submitted for publication with authors from the University of Pittsburgh and Command Surgeon of the US Army Special Operations Command. The authors submit the paper with the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the peer-reviewed journal. All named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and all must have critically reviewed its content and have approved the final version submitted for publication.

Phase 3: To validate THOR3's human performance program to modify injury mitigating and human performance characteristics identified in Phase 2

Methods: Upon receipt of the Phase 1 and Phase 2 results, USASOC's THOR3 human performance personnel will evaluate the biomechanical, musculoskeletal, physiological, tactical, and injury data and refine its current human performance program to address the injury mitigating and human performance characteristics. A randomized controlled clinical trial intervention design will be implemented with USASOC Operator units assigned to either an experimental (revised THOR3 training) or control (current THOR3 training) group as part of the intervention. Pre- and post-testing of biomechanical, musculoskeletal, physiological, and tactical characteristics will be performed as outlined in Phase 2. THOR3's revised human performance program will be tested in a 12 week intervention and instructed by THOR3 human performance personnel as part of their daily training of the Operators. Based on several individual power analyses performed for the dependent variables (biomechanical, musculoskeletal, physiological) to be assessed during this aim, quadriceps strength data yielded the most conservative estimate and was selected to calculate the sample size. Previously collected data (Quadriceps Strength Mean: 271.7 ± 59.3) and an expected effect size improvement of 0.69 following the intervention indicated a total of 150 subjects will be needed to achieve a power of 0.80 with a probability of $p < 0.05$. A total of 200 subjects will be recruited to account for attrition. Phase 3 research activities will be performed Y3Q2-Y3Q4.

Deliverables: The data from this aim will test the effectiveness of the revised THOR3 program to modify the identified biomechanical, musculoskeletal, physiological, and tactical characteristics that predict injury, physical readiness, and tactical performance. Based upon the results of this aim, the THOR3 program may be augmented to address insufficient findings prior to formal implementation into USASOC Operator training and testing for injury mitigation in Phase 4. The data from this aim will be submitted for publication with authors from the University of Pittsburgh and Command Surgeon of the US Army Special Operations Command. The authors submit the paper with the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the peer-reviewed journal. All named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and all must have critically reviewed its content and have approved the final version submitted for publication.

Overall Deliverables and Way Forward: Phase 4 of the research (not part of the current submission- to be submitted under a separate SOW) will test the effectiveness of the THOR3 program to mitigate unintentional musculoskeletal injuries with a larger prospective study. Injury data will be evaluated pre- and post-implementation of the revised THOR3 program and between like tactical units. This phase of research will incorporate subjects from across USASOC and evaluate stratified data based on tactical requirements.

Key Research Accomplishments

Award Period of Performance

A no cost extension was applied to the research grant with an expiration date of 21 NOV 14.

Statement of Work

Phase 1 Aim 1: To perform an epidemiological analysis of the unintentional musculoskeletal injuries sustained by USASOC Operators

Injury data were obtained from the Armed Forces Health Surveillance Center for 16,042 subjects. Data were reported as International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) codes. Injury data were filtered to identify all musculoskeletal injuries or conditions. Injury data were filtered again as primarily preventable acute or overuse musculoskeletal injuries/conditions.

Injury data were analyzed based on calendar year for 2009-2011 relative anatomical regions.

Injury Anatomic Region	Medical Reported Relative % 2009 (566 Injuries)	Medical Reported Relative % 2010 (583 Injuries)	Medical Reported Relative % 2011 (932 Injuries)	Medical Reported Relative % Cumulative
Lower Extremity	28.3	31.2	25.9	28.0
Upper Extremity	18.0	14.8	19.8	17.9
Spine	45.9	44.9	44.1	44.8
Head/Face	0.0	0.0	0.6	0.3
Torso	0.0	0.0	0.0	0.0
Unidentified	7.8	9.1	9.5	8.9

The data were further analyzed based on anatomical sub-regions.

Injury Anatomic Region	Anatomic Location	Medical Reported Frequency (%) 2009	Medical Reported Frequency (%) 2010	Medical Reported Frequency (%) 2011	Medical Reported Frequency (%) Cumulative
Lower Extremity	Thigh	0.9	2.9	3.0	2.4
	Lower Leg	13.1	9.9	9.0	10.4
	Hip	0.5	1.4	0.9	0.9
	Knee	3.9	1.7	4.5	3.6
	Ankle/Foot/Toes	9.4	13.6	8.3	10.0
Upper Extremity	Hands/Fingers	0.7	0.5	2.7	1.5
	Upper Arm	0.5	1.5	1.2	1.1
	Forearm	1.8	1.2	3.9	2.5
	Shoulder	10.6	9.3	8.0	9.1
	Elbow	0.0	0.9	0.1	0.3
	Wrist	0.0	0.5	0.8	0.5
Spine	Cervical	8.7	7.9	6.8	7.6
	Thoracic	4.4	4.1	4.4	4.3
	Lumbopelvic	21.4	19.9	21.6	21.0
	Other	11.5	13.0	11.4	11.9
Head/Face		0.0	0.0	0.0	0.0
Torso	Chest	0.0	0.0	0.6	0.3
	Abdomen	0.0	0.0	0.0	0.0
	Other	0.0	0.0	0.0	0.0

Injury Classification	
Chronic	53.98%
Acute	43.43%
Unknown	2.59%

Phase 1 Aim 2: To describe the tactical and physical tasks which result in the greatest proportion of unintentional musculoskeletal injuries

Additional injury data were obtained from USASOC for injuries sustained during the time period 21 DEC 11 – 24 OCT 12. Data collected by USASOC will be used to identify mechanisms of injuries, location distribution (deployment, garrison), anatomical distribution, and injury type (acute/chronic).

Distribution of MOI	
Training - Physical Training (Individual)	17.93%
Gradual Onset	12.55%
Training - Physical Training (Unit)	9.76%
Training - Airborne Operations	9.56%
Unknown	7.17%
Combat - Battle Injury	5.78%
Combat - Non-Battle Injury	5.38%
Recreational Sports	4.98%
Training - Schools (HALO,SERE,Airborne,Ranger,Etc.)	4.78%
Insidious Onset	3.98%
Non-Military Activity	3.39%
Training - Physical Training (THOR3)	2.79%
N/A	2.59%
Combatives	2.59%
MVA	2.39%
Other	2.19%
Training - Field Exercise	2.19%

Distribution of Location	
Theater	11.16%
Garrison/Unknown	88.84%

Distribution of Injuries	
L Spine	22.91%
Knee	16.93%
Shoulder	15.14%
Ankle/Foot	14.54%
C Spine	6.18%
Leg	5.78%
Hip	4.78%
T Spine	4.58%
N/A	2.59%

In consultation with the USASOC physical therapy staff specific injuries for each tactical school were identified relative to the tasks performed by USASOC Operators. For each task injuries and probable mechanisms of injury were identified.

Ruck Marching

Anatomic Location	Specific Injuries	Probable Causes
Knee	Patellofemoral Pain Syndrome	Running overuse Improper footwear Generalized lower extremity inflexibility Hip abductor weakness Changing running gait/ Overpronation
	Iliotibial Band Syndrome	Excessively tight iliotibial band Hip musculature weakness (e.g. gluteus medius) Poor gait pattern/ Overpronation
	Tibial Stress Fracture	Overloading the bone due to excessive running
	Posterior Tibialis Stress Syndrome	Increasing running volume too quickly Inadequate footwear Overpronation or underpronation Lack of flexibility in the lower extremity, particularly around the ankle joint
Ankle/ Foot	Achilles Tendinopathy	Increasing running volume too quickly/ too little recovery time Lack of flexibility in the gastroc/soleus complex Changing footwear or running surface
	Plantar Fasciitis	Lack of flexibility in the gastroc/soleus complex Inadequate footwear Poor gait pattern
Lumbar Spine	Muscular Strain/ Disc Injury	Prolonged, excessive forward trunk flexion while carrying loads for long duration Places excessive strain and force on lumbosacral complex

Running

Anatomic Location	Specific Injuries	Probable Causes
Knee	Patellofemoral Pain Syndrome	Running overuse Improper footwear Generalized lower extremity inflexibility Hip abductor weakness Changing running gait/ Overpronation
	Iliotibial Band Syndrome	Excessively tight iliotibial band Hip musculature weakness (e.g. gluteus medius) Poor gait pattern/ Overpronation
	Tibial Stress Fracture	Overloading the bone due to excessive running
	Posterior Tibialis Stress Syndrome	Increasing running volume too quickly Inadequate footwear Overpronation or underpronation Lack of flexibility in the lower extremity, particularly around the ankle joint
Ankle/ Foot	Achilles Tendinopathy	Increasing running volume too quickly/ too little recovery time Lack of flexibility in the gastroc/soleus complex Changing footwear or running surface
	Plantar Fasciitis	Lack of flexibility in the gastroc/soleus complex Inadequate footwear Poor gait pattern

Sprinting

Anatomic Location	Specific Injuries	Probable Causes
Hamstring	Hamstring Strain (Grade 1-3) Chronic strains due to lack of treatment	Lack of hamstring flexibility and/or strength Lack of dynamic and active flexibility training

Jumping

Anatomic Location	Specific Injuries	Probable Causes
Knee	Patellar Tendinitis	Overuse places chronic stress on patella tendon Lack of lower extremity flexibility Lack of sufficient quadriceps strength and lack of eccentric training of quadriceps

Landing

Anatomic Location	Specific Injuries	Probable Causes
Knee	Acute sprains and tears of ligaments (ACL, MCL, meniscus most common)	Poor landing mechanics due to natural biomechanics/ anthropometrics and/ or lack of landing training
Ankle/ Foot	Acute ankle sprains	Poor landing mechanics Lack of muscular strength surrounding ankle joint Decreased mechanoreceptor function/ poor neuromuscular control and proprioception
Lumbar Spine	Acute or chronic facet joint sprain/ arthopathy	Limited joint accessory mobility Lack of flexibility in the lumbosacral complex Cumulative forces associated with landing

<u>Weight Lifting</u>

Anatomic Location	Specific Injuries	Probable Causes
Shoulder	Rotator cuff tendinopathy	Repetitive overhead use Poor scapular muscle activation Lack of rotator cuff strength Lack of rotator cuff stability Poor active and passive glenohumeral range of motion
Lumbar Spine	Degenerative disc disease, facet arthopathy, muscular strains, and arthritis	Poor lifting mechanics Inflexibility of the lumbo-pelvic-hip complex in addition to limited joint accessory mobility

Static Line Parachuting

Anatomic Location	Specific Injuries	Probable Causes
All lower extremity is at risk for injury during this exercise	Foot fractures Ankle sprains Tibia or fibula fractures Knee ligament sprains or tears Lumbar spine strains/ sprains/ disc injury	Improper parachute landing technique Landing hazards Improper exit technique Improper gear configuration

Special Forces Combat Diving

Anatomic Location	Specific Injuries	Probable Causes
Most reported medical problems are not orthopedic in nature	Inner ear barotrauma Pulmonary barotrauma Arterial gas embolism Decompression sickness	
Shoulder	Rotator cuff tendinopathy/ impingement	Overtraining or ramping up training too quickly Rotator cuff becomes rapidly fatigued Scapulohumeral rhythm becomes compromised Poor swimming technique

Special Forces Mountain Warfare School

Anatomic Location	Specific Injuries	Probable Causes
Many medical issues beyond musculoskeletal injuries mainly due to the high altitude and surrounding environment		
See Ruck March Injuries		
Shoulder	Rotator cuff tendinopathy/ impingement Biceps tendinitis SLAP tears	Overtraining or ramping up climbing activities too quickly Rotator cuff becomes fatigued during long climbs Scapulohumeral rhythm becomes compromised Poor climbing technique
Elbow	Medial and lateral epicondylitis	Ramping up climbing activity too quickly Wrist flexors and extensors are not adequately strengthened and conditioned prior to activity

Special Forces Advanced Urban Combat

Anatomic Location	Specific Injuries	Probable Causes
Musculoskeletal injuries are difficult to predict. They will be acute injuries associated with running, jumping, landing, and combat.		

Phase 2 Aim 1: To prospectively identify biomechanical, musculoskeletal, physiological, and nutritional risk factors for injury in USASOC Operators

Phase 2 Aim 2: To determine the relationship between previous history of unintentional musculoskeletal injury and biomechanical, musculoskeletal, physiological, and tactical characteristics

Phase 2 Aim 3: To identify suboptimal biomechanical, musculoskeletal, physiological, tactical, and nutritional characteristics for physical readiness in the USASOC Operator

Nutrition

A nutritional analysis was performed for each subject through a nutrition/exercise history interview and a self-reported 24 hour dietary recall. Nutrition history included weight/body composition goals, physical training, eating habits, fluid consumption, frequency of foods, and supplement usage. Food/fluid habits relative to daily food consumption, prior to, during, and after physical training were compared to the profiles of an athletic population under similar physical demands. Data was analyzed to determine if the nutritional needs of operators were met in reference to total energy consumption, macronutrient distribution, and eating/hydration habits during physical training. Additionally, frequency of supplement usage and type were reported.

Laboratory Data

Subjects enrolled in the study underwent a comprehensive human performance assessment for injury prevention and optimal physical readiness to evaluate biomechanical, musculoskeletal, physiological, and nutritional characteristics relative to injury and performance. Specific testing included musculoskeletal strength and flexibility, balance, aerobic capacity and lactate threshold, anaerobic power and capacity, body composition, movement patterns during functional (tactical) tasks, nutritional history, and injury history.

Energy Requirements for Physical Training and Weight Goals

Purpose:
To determine the amount of calories consumed on a daily basis and compare it to the calories required to fuel daily physical training as well as obtain the Operators weight and body composition goals.

Background:
Energy expenditure data of military personnel reported in the literature has ranged from 3100 to over 8000 kcals per day. The large range reflects differences not only in the volume, intensity, operational and environmental demands of the physical activity being performed, but in the variety methods used to obtain the data. Although the daily total energy expenditure (TEE) of the Operator has not been quantified, estimations of energy needs can be calculated using the Cunningham equation, which has been previously validated in athletic populations. The Cunningham equation uses fat free mass and an activity factor to calculate TEE.

Data and Results:

Weight Goals and Energy Intake

- 23% of Operators wanted to gain weight (Average body fat = 14 ± 4%)
  - 40% of these Operators consumed excess calories for weight gain
  - 20% of these Operators consumed enough calories to maintain weight
  - 40% of these Operators consumed enough calories to meet their needs
- 41% of Operators wanted to lose weight (Average body fat = 18 ± 6%)
  - 61% of these Operators consumed the adequate calories for weight loss
  - 17% of these Operators consumed enough calories to maintain weight
  - 22% of these Operators consumed excess calories
- 36% of Operators wanted to maintain current weight (Average body fat = 14 ± 4%)
  - 25% of these Operators consumed adequate calories to meet maintain current weight
  - 19% of these Operators consumed excess calories
  - 56% of these Operators consumed enough calories to meet their needs

Summary:
Currently, more Operators reported wanting to lose weight (41%) than maintaining (36%) or gaining weight (23%). The majority (60%) of Operators wanting to gain weight were not consuming adequate calories to meet their goals. Additionally only 25% of Operators looking to maintain their weight were currently meeting between 90-110% of their estimated needs. More than half (61%) the Operators wanting to lose weight were consuming less than 90% of their estimated energy needs.

**Important to note, underreporting food intake may also contribute to the high number of individuals who have a reported intake less than their estimated energy requirements. In addition, estimates of energy expenditure are based on a formula and not measured energy needs.

Carbohydrate Requirements for Physical Training

Purpose:
Carbohydrates should be consumed based on training time and body weight in order to individualize specific muscle fuel needs for the Operators. The aim is to achieve carbohydrate intakes to meet the fuel requirements of the training program and to optimize restoration of muscle glycogen stores between workouts so that Operators are able to perform maximally and are combat ready more quickly.

Background:
Carbohydrate is the major fuel source for skeletal muscle and the brain. In the muscle, stored carbohydrate (glycogen) can be used for both anaerobic (short-term, high-intensity) and aerobic (endurance) activity. During prolonged strenuous physical activity, muscle glycogen and blood glucose are the major substrates for oxidative metabolism. A retrospective review of 11 different field studies involving 781 military personnel found an average CHO intake of 290 ± 70 grams per day, well below the NATO panel recommendation of >450 grams per day needed for glycogen synthesis. Research has shown that CHO intake will also improve performance on military tasks.

Carbohydrate requirements will be estimated based physical training using the following:

Grams Carbohydrate/kg body weight/day	Training
4-5 g/kg/day	Typical US diet
5-7 g/kg/day	General training activities
7-10 g/kg/day	Endurance athletes
10-12 g/kg/day	Ultra endurance exercise (4-6 hr/day)

Data and Results:
- 29% of Operators met or exceeded the amount of carbohydrate in a typical US diet (4-5 g/kg body weight/day)
- 18% of Operators met or exceeded the recommended amount of carbohydrate for general training needs (5-7 g/kg body weight/day)
- 14% of Operators met the NATO recommendation of >450 g/day

Summary:
When carbohydrate reserves are depleted during/after physical training and are not sufficiently replaced with adequate amounts of daily carbohydrate, there is a switch to a fat-predominant fuel metabolism which is characterized by muscle and central fatigue and the inability to maintain power output. Ultimately this results in a decrease in physical performance. In order for Operators to train at a higher level, it is vital they consume sufficient carbohydrates on a daily basis. Currently, only 18% of Operators are eating the recommended amount of carbohydrate on a daily basis to replace used glycogen stores from physical training. The majority (~82%) of the tested Operators are not currently meeting the recommended amount of carbohydrate to optimally replace muscle glycogen. Further, 71% of Operators are not even eating the recommended amount of carbohydrates for the “average adult male” (low active).

Protein Requirements for Increasing Muscular Strength and Endurance

Purpose:
Examine protein intake as it relates to increasing muscular strength and power

Background:
The 0.8 g protein per kilogram body weight (Recommended Daily Allowance RDA) represents a liberal requirement believed to be adequate for all people. A protein intake of between 1.2 and 1.7 g/kg of body mass should adequately meet the possibility for added protein needs during strenuous physical training. Protein requirement for strength trained individuals is on the higher side of the range (1.6-1.7 g/kg body weight) allowing additional protein necessary to increase muscle mass, strength and or power. Equally or more important to increase muscle strength and size is the provision of additional calories above the amount necessary for maintenance.

<u>Protein Requirements</u>: 1.2-1.7 g/kg body weight for endurance to strength trained athletes

Data and Results:
- 49% of Operators fell within recommended protein requirements
    - 18% of Operators fell below the recommended range
    - 33% of Operators exceeded the recommended range
- 98% of Operators met or exceeded the RDA (0.8 g protein/kg body weight) for the "average adult male"

Summary:
Currently 82% of the tested Operators met or exceeded their estimated protein requirements for moderate to heavy physical training. Of these Operators, 27% of them also met or exceeded their estimated energy requirements, which provides the right environment for increasing muscle strength and size. Seventy-three percent of Operators who met or exceeded their protein requirements did not meet their estimated energy requirements and therefore may be metabolizing the excess protein to meet their energy needs. Eighteen percent of Operators did not consume adequate protein and all of them did not consume adequate calories. Consuming suboptimal calories and protein will result in decreased body mass, muscle strength, size and power output.

Distribution of Fat in the Diet

Purpose:
In order to maximize physical performance, it is essential to consume adequate calories, carbohydrate and protein in the diet. Once carbohydrate and protein needs are met, the balance of calories can be supplied by fat in the range of 0.8-1.0 g (moderate PT) to 2.0 g (heavy PT longer duration >4 hours/day) fat per kg body weight.

Background:
Fat along with carbohydrate is oxidized in the muscle to supply energy to the exercising muscles. The extent to which these sources contribute to energy expenditure depends on a variety of factors, including exercise duration and intensity, nutritional status, and fitness level. In general as exercise duration increases, exercise intensity decreases and more fat is oxidized as an energy substrate. During high intensity physical training, predominantly carbohydrate is oxidized to fuel the muscles. To improve physical performance, individuals need to consume enough calories, carbohydrates, and protein to support the demands of training in order to train at a higher level. In planning a diet to provide the nutrients to support the training program, carbohydrate and protein needs are determined first and then the remaining calories are designated to fat which typically ranges from 0.8-2.0 g fat per kg body weight based on caloric needs, body composition goals and duration and intensity of training.

From a health prospective, the Dietary Reference Intakes (DRIs) have defined an Acceptable Macronutrient Distribution Range (AMDR) for fat as 20-35% of daily energy needs for all adults. The AMDR is defined as a range in intakes for a particular energy source that is associated with reduced risk of chronic diseases while providing adequate intake of essential nutrients.

Data and Results:
- 76% of Operators consumed greater than 0.8 g to $\leq$ 2.0 g fat per kg body weight (recommended range)
- 18% of Operators consumed less than 0.8 g fat per kg body weight, and of these 100% consumed insufficient energy (kcals) to meet energy needs
- 6% of Operators exceeded 2.0 g fat per kg body weight
- 69% of Operators consumed greater than 30% of calories from fat
- 10% of Operators exceeded their estimated energy requirements. These individuals also had the highest consumption of fat (1.6-2.8 g/kg body weight).
- 24% of Operators met or exceeded their energy requirement. Of these Operators,
  - 25% met their protein requirement, failed to meet carbohydrate requirement, and exceeded the 1.0 g fat per kilogram body weight
- 76% of Operators did not meet their energy requirements. Of these Operators,
  - 10% failed to meet both carbohydrate and protein requirements, yet consumed >1.0 g fat per kilogram body weight
  - 8% failed to meet the recommended amounts for all macronutrients (carbohydrate, protein and fat)
  - 62% failed to meet carbohydrate requirements but either met or exceeded protein or fat requirements

Summary:
To train at an optimal level, it is important to consume sufficient calories, carbohydrates, protein and some fat. However, if foods high in fat replace carbohydrate and protein foods in the diet, such that these two macronutrients fall below recommended amounts, it may impair physical performance. It is recommended that these Operators decrease the amount of fat in the diet and increase carbohydrate and protein foods (lower in fat) to better fuel their bodies for physical training and to improve body composition.

From a health prospective, 69% of Operators consumed a diet that is >30% of calories from fat. High fat diets increase the risk for overweight, high body fat, high blood pressure, diabetes mellitus, and cardiovascular disease. Decreasing the overall fat content of the diet and replacing the calories with high carbohydrate, moderate protein foods (that are low in fat), would decrease health risk and improve physical training.

Adequate Fluids During Exercise to Stay Hydrated and Maintain Energy

Purpose: Examine fluid habits before, during and after exercise

Background:
The goal is to consume adequate fluids to avoid dehydration but not in excess to avoid water intoxication. The Operator should be well hydrated when beginning exercise and accustomed to consuming fluid at regular intervals (with or without thirst) during training sessions to minimize fluid losses that may result in a decrease in physical performance. If time permits, consumption of normal meals and beverages will restore euhydration. Individuals needing rapid and complete recovery from excessive dehydration can drink approximately 1.5 L of fluid per kg of body weight lost (23 oz per pound). Consuming beverages and snacks with sodium will help expedite rapid and complete recovery by stimulating thirst and fluid retention.

Data and Results:
Fluids Before Physical Training

- 81% of Operators consumed water
- 15% of Operators consumed other drinks (coffee, diluted sports drink, diet soda)
- 5% of Operators consumed sports drinks

Fluids During Physical Training

- 93% of Operators consumed water
- 4% of Operators consumed other drinks (pre-workout sports drink, diluted sports drink)
- 3% of Operators consumed sports drinks

Fluids After Physical Training

- 90% of Operators consumed water
- 6% of Operators consumed sports drinks
- 3% of Operators consumed other drinks (protein shakes, energy drinks, juice)

Summary:
The majority of Operators (93%) consume some fluid before physical training. The beverage of choice is water (81%), followed by "other" drinks. The majority of Operators do regularly drink fluids during PT. Water is the preferred beverage (93%), however if PT lasts longer than 60 minutes and is rigorous, it may be more beneficial to consume fluids with carbohydrates and electrolytes. Ideally, beverages consumed during training lasting longer than 60 minutes should contain 6-8% carbohydrate, 10-20 mEq sodium and chloride (constitution of most Sports drinks). Sodium and carbohydrate help speed replenishment of fluid and energy reserves as well as replace sodium lost due to sweating. All Operators consumed fluids after physical training. The majority drank water, followed by sports drinks. Ideally, the beverage should contain fluid, carbohydrate, electrolytes and a small amount of protein. For example, low fat chocolate milk, fruit smoothie or sports drinks that contain protein are good choices. Water along with a snack or meal with carbohydrate, protein and electrolytes is also sufficient. Consuming a post exercise beverage or snack/meal containing carbohydrate and protein will provide the essential nutrients for faster muscle recovery.

Timing and Type of Post Physical Training Food Intake

Purpose: Examine protein intake and timing after physical training

Background: Immediately after (within 30 minutes) physical training, it is recommended to consume a snack/meal that contains both carbohydrate and a small amount of protein. Nutrient consumption with resistance training stimulates muscle protein synthesis and inhibits the exercise induced muscle protein breakdown, thereby muscle mass is gradually increased. Consuming a post exercise snack or meal containing carbohydrate and protein will provide the essential nutrients for faster muscle recovery. Expedited muscle recovery allows an individual to sustained higher physical work capacity (strength and endurance) in subsequent periods of exertion, thus increasing combat readiness.

Data and Results:

Timing and Content of Pre-Training Snack

- 56% of Operators consumed a pre-training snack or meal

TYPE of Snack/Meal

- 59% of the pre-training snack/meals contained both carbohydrate and protein
- 3% of the pre-training snacks contained only protein
- 33% of the pre-training snacks contained only carbohydrate
- 8% NA

TIMING of Snack/Meal

- 20% consumed a snack/meal less than 30 minutes before PT
- 69% consumed a snack/meal between 30 mins-1 hour before PT
- 11% consumed a snack/meal between 1-2 hours before PT

Timing and Content of Post-Training Snack

- 95% of Operators consumed a post-training snack or meal

TYPE of Snack/Meal

- 81% of the post-training snack/meals contained both carbohydrate and protein
- 14% of the post training snacks contained only protein
- 5% of the post-training snacks contained carbohydrate only

TIMING of Snack/Meal

- 20% consumed a recovery snack/meal <30 minutes following PT
- 69% consumed a recovery snack/meal between 30 mins-1 hours following PT
- 11% consumed a recovery snack/meal between 1-2 hours following PT

Summary:
Fifty-six percent of Operators reported eating a snack or light meal before participating in physical training. Of those Operators who consume a snack/meal, 89% are eating the snack/meal within one hour of PT and 59% are consuming a snack/meal that contains carbohydrates and protein such as oatmeal, cereal with fruit, yogurt, full breakfast meal, energy bars, protein shakes, sandwiches and nuts. Consuming food prior to PT will provide additional energy and may help to delay fatigue, allowing an Operator to perform for a longer duration and/or at a higher intensity for longer periods of time. In addition, including protein prior to exercise may help to minimize the catabolic effect of strenuous exercise on skeletal muscle.

Ninety-five percent of Operators reported eating a snack or a meal after completion of physical training. Of these Operators, 81% consumed a snack/meal that contained both carbohydrate and protein, such as cereal, milk, fruit, eggs, sausage, toast, or yogurt. Twenty percent reported consuming the meal within 30 minutes of completing PT. Ideally, consuming food that contains a moderate amount of carbohydrate and a small amount of protein within 30 minutes will expedite muscle glycogen resynthesis and help to reduce muscle protein breakdown. This is especially important for Operators participating in subsequent training bouts within 8 hours.

Dietary Supplement Usage

Purpose:
To determine the type and usage of dietary supplements.

Background:
The use of dietary supplements to promote health and improve physical performance has become increasingly popular among members of the military. The results of surveys indicate usage ranges from 37-81% (Institute of Medicine, 2008). Supplements available to service members range from those that might impart beneficial effects to heath and performance with negligible side effects to other that have uncertain benefit and might be potentially harmful especially give the unique environmental and physical demands of military warfare. Currently, data on dietary supplement usage in special operation forces is lacking.

Data and Results:

Dietary Supplement Usage

- 73% of Operators consumed dietary supplements
    - 32% protein supplements (whey protein, Endurox, Myoplex, soy protein, amino acids)
    - 20% Multivitamin/mineral (individual vitamin/mineral)
    - 14% Fish oils/flax seed/omega-3 fatty acids
    - 10% Glucosamine Chondroitin/Joint Juice
    - 5% Caffeine/Energy drinks
    - 3% Creatine
    - 3% Pre-workout supplement (NO-Explode, Jack-3D)
    - 1% Carbohydrate Gels/Blocks

Summary:
The results of our survey indicate that 73% consumed either a dietary supplement and/or a vitamin mineral supplement on a regular basis. The majority of Operators consumed a protein type supplement. Consuming a meal with protein and carbohydrate before and after hard physical training will help to replace used fuel stores and help rebuild the muscle more quickly. Three percent consumed Jack-3D, NO-Explode or some type of pre-workout supplement. The effectiveness of NO-Explode as an ergogenic aid is not supported by scientific literature nor have the safety issues been adequately addressed in the athletic or military populations. Jack-3D contains Geranium Stem, which behaves like an amphetamine and when combined with caffeine is a potent stimulant that may lead to serious injury or death. Geranium Stem is a banned substance on the NCAA, WADA supplement list, as well as being banned from military bases. The DOD has ordered an end to all on-base sales of supplements that contain dimethylamylamine (DMAA), which is found in geranium stem extract.

Musculoskeletal Strength
Shoulder Internal Rotation (IR) and External Rotation (ER) Strength

Testing methodology:
Biodex System 3 isokinetic dynamometer (Biodex Medical, Shirley, NY)
5 repetitions
Average peak torque/body weight (BW)

Purpose: Examine rotator cuff strength

Background: Proper IR and ER rotator cuff strength is critical for the performance of demanding overhead tasks and maneuvers involving the upper extremity, and is critical for the prevention of shoulder overuse injury. The glenohumeral joint is dependent upon the health of the rotator cuff as a source of dynamic joint stabilization. Deficiencies in strength or reciprocal balance of the rotator cuff musculature will predispose the shoulder joint to altered kinematics, leading to acute and/or chronic joint instability, impingement syndromes, and rotator cuff tears. Further, shoulder IR and ER strength testing consistently detects persistent and potentially dangerous rotator cuff weakness after previous injury.

Data and Results:

RIGHT

	IR (% BW)	ER (% BW)	ER/IR (Ratio)
Top 10th %tile 3SFG	79.3	48.4	--
Top 25th %tile 3SFG	66.7	43.8	--
50th %tile 3SFG	61.0	40.4	--
Bottom 25th %tile 3SFG	51.9	36.4	--
Athlete*	53.0	40.0	0.77
Triathletes	64.3 ± 9.7	46.5 ± 6.9	0.73 ± 0.09
3SFG	61.0 ± 11.8	40.6 ± 7.1	0.68 ± 0.12
5SFG	65.4 ± 14.7	45.4 ± 6.7	0.72 ± 0.16

LEFT

	IR (% BW)	ER (% BW)	ER/IR (Ratio)
Top 10th %tile 3SFG	77.7	48.8	--
Top 25th %tile 3SFG	62.8	44.2	--
50th %tile 3SFG	57.2	38.9	--
Bottom 25th %tile 3SFG	51.8	35.9	--
Athlete*	53.0	40.0	0.77
Triathletes	65.5 ± 13.6	44.5 ± 7.3	0.69 ± 0.12
3SFG	58.7 ± 10.9	40.7 ± 7.5	0.70 ± 0.11
5SFG	61.3 ± 17.8	40.1 ± 7.6	0.68 ± 0.13

***Male collegiate swimmers (Oyama, 2006).**

Summary: The average internal rotation strength was consistent with the triathletes, up to 29% greater than the athletes, and 12% less than the top 10th percentile of Operators. The average external rotation strength was up to 13% less than the triathletes, 18% less than the athletes, and up to 19% less than the top 10th percentile of Operators. Suboptimal strength ratios were identified in 64% external rotation/internal rotation strength ratio, where suboptimal was defined as greater than a 10% deficit of the athlete average (<0.69 or >.85, respectively). Asymmetrical differences were identified in 40% of the Operators.

Shoulder Protraction, Retraction and Elevation Strength

Testing methodology:
Biodex System 3 isokinetic dynamometer (Biodex Medical, Shirley, NY)
5 repetitions
Average peak torque/BW

Purpose: Examine scapular stabilizer strength

Background: Scapular stabilization strength is critical for the performance of demanding upper limb tasks. Scapular protractor-retractor, and elevation muscle performance is critical for shielding the shoulder complex from potentially injurious forces. The shoulder complex is dependent on the health of the scapular stabilizers as sources of dynamic joint stabilization. Deficiencies in strength or reciprocal balance of the scapular stabilizer musculature will predispose the shoulder complex to altered kinematics, leading to acute and/or chronic shoulder joint instability, shoulder impingement syndromes, rotator cuff tears, trapped nerves, and occluded blood supply throughout the arm. Further, shoulder protractor-retractor, and elevation strength testing consistently detects persistent and potentially dangerous muscle weakness after previous upper limb injury.

Data and Results:

RIGHT

	Protraction (% BW)	Retraction (% BW)	Pro/Ret (Ratio)	Upper Trapezius (% BW)
Top 10th %tile 3SFG	603.1	646.1	--	666.5
Top 25th %tile 3SFG	555.6	597.8	--	610.0
50th %tile 3SFG	472.8	469.1	--	548.9
Bottom 25th %tile 3SFG	396.0	358.4	--	483.2
Athlete*	494.0	469.0	1.18	666.5
3SFG	473.4 ± 104.0	466.3 ± 140.5	1.06 ± 0.23	538.7 ± 106.0

LEFT

	Protraction (% BW)	Retraction (% BW)	Pro/Ret (Ratio)	Upper Trapezius (% BW)
Top 10th %tile 3SFG	614.4	640.4	--	640.8
Top 25th %tile 3SFG	555.2	578.3	--	585.2
50th %tile 3SFG	479.0	499.4	--	523.9
Bottom 25th %tile 3SFG	350.8	383.4	--	471.7
Athlete*	494.0	469.0	1.18	640.8
3SFG	457.4 ± 115.3	480.5 ± 140.9	1.01 ± 0.33	525.5 ± 90.5

***Healthy overhead athletes (Cools, 2005).**

Summary: The average protraction strength was consistent with the athletes and up to 35% less than the top 10th percentile of Operators. The average retraction strength was up to 37% less than the athletes and up to 38% less than the top 10th percentile of Operators. The average elevation strength was up to 22% less than the athletes and up to 22% less than the top 10th percentile of Operators. Suboptimal protraction/retraction strength ratios were identified in 85% of Operators and was defined as greater than a 10% deficit of the athlete average (<1.06 or >1.30 for ratios).

Knee Flexion and Extension Strength

Testing methodology:
Biodex System 3 isokinetic dynamometer (Biodex Medical, Shirley, NY)
5 repetitions
Average peak torque/BW

Purpose: Examine knee flexion and extension strength

Background: Adequate strength of the hamstring and quadriceps muscle groups is vital for the safe and effective performance of potentially injurious landing tasks and change-of-direction maneuvers associated with tactical operations and physical training. These muscle groups contribute to the dissipation of imposed forces and neuromuscular control of the knee joint during demanding lower extremity activities. Maintenance of appropriate strength ratios between the hamstring and quadriceps muscle groups may minimize the risk factors associated with traumatic and overuse lower extremity injuries during training.

Data and Results:

RIGHT

	Flexion (% BW)	Extension (% BW)	Flex/Ext (Ratio)
Top 10th %tile 3SFG	166.5	310.7	--
Top 25th %tile 3SFG	142.1	261.9	--
50th %tile 3SFG	129.4	231.0	--
Bottom 25th %tile 3SFG	110.6	204.5	--
Athlete*	170.0	270.0	0.65
Triathletes	128.0 ± 22.6	242.1 ± 50.4	0.55 ± 0.09
Normative	--	--	0.60-0.80
3SFG	131.0 ± 24.3	237.2 ± 44.3	0.56 ± 0.09
5SFG	135.3 ± 30.4	255.9 ± 47.5	0.53 ± 0.09

LEFT

	Flexion (% BW)	Extension (% BW)	Flex/Ext (Ratio)
Top 10th %tile 3SFG	158.5	291.8	--
Top 25th %tile 3SFG	145.3	259.7	--
50th %tile 3SFG	122.0	222.8	--
Bottom 25th %tile 3SFG	111.7	199.2	--
Athlete*	170.0	270.0	0.65
Triathletes	128.5 ± 23.2	241.3 ± 42.9	0.53 ± 0.06
Normative	--	--	0.60-0.80
3SFG	± 25.9	229.7 ± 44.6	0.56 ± 0.08
5SFG	± 24.2	247.8 ± 41.6	0.51 ± 0.07

***Rugby union players (Newman, 2004).**

Summary: Average knee flexion strength was up to 33% lower than the athlete, consistent with triathletes, and up to 24% lower than the top 10th percentile of Operators. Average knee extension strength was up to 17% lower than the athlete value and consistent with the triathlete value, and up to 28% less than the top 10th percentile of Operators. Suboptimal flexion/extension ratio, defined as greater than a 10% deficit of the athlete average (<0.59 or >0.72), was identified in 64% of the Operators. Asymmetrical differences were identified in 47% of Operators for knee flexion strength and 31% of Operators for knee extension strength.

Ankle Inversion and Eversion Strength

Testing methodology:
Lafayette handheld dynamometer
Average of 3 measurements (Kg/BW)

Purpose: Examine ankle inversion and eversion strength

Background: Ankle invertors and evertors serve a critical role in providing dynamic stabilization and neuromuscular control to the ankle joint during closed kinetic chain activities such as those experienced during the demanding tasks encountered by Special Operations Soldiers during tactical training. Incorporating strengthening exercises for these important muscle groups will dramatically impact the deficits that are seen in this variable and likely significantly decrease the risk factors associated with recurrent ankle injuries reported.

Data and Results:

RIGHT

	Inversion (% BW)			Eversion (% BW)			EVER/INVER (Ratio)		
Top 10th %tile 3SFG	37.3			39.8			--		
Top 25th %tile 3SFG	34.0			36.9			--		
50th %tile 3SFG	31.3			33.7			--		
Bottom 25th %tile 3SFG	25.9			31.2			--		
Triathletes	23.6	±	3.7	21.5	±	2.3	1.10	±	0.13
3SFG	30.4	±	5.8	33.9	±	5.4	0.90	±	0.13
5SFG	37.9	±	4.9	34.2	±	5.9	1.11	±	0.17

LEFT

	Inversion (% BW)			Eversion (% BW)			EVER/INVER (Ratio)		
Top 10th %tile 3SFG	42.6			36.7			--		
Top 25th %tile 3SFG	36.7			32.6			--		
50th %tile 3SFG	33.9			29.5			--		
Bottom 25th %tile 3SFG	31.2			26.9			--		
Triathletes	23.2	±	4.8	21.6	±	3.5	1.09	±	0.18
3SFG	33.9	±	5.9	29.7	±	5.3	1.15	±	0.15
5SFG	37.9	±	5.6	32.9	±	4.9	1.15	±	0.14

Summary: Average ankle inversion strength was up to 30% higher than the triathletes and 21% lower than the top 10^{th} percentile of Operators. Average ankle eversion strength was up to 36% higher than the triathletes and 21% lower than the top 10^{th} percentile of Operators. Strength ratio deficits were identified in 51% of Operators for eversion and 62% for inversion.

Torso Flexion and Extension Strength

Testing methodology:
Biodex System 3 isokinetic dynamometer (Biodex Medical, Shirley, NY)
5 repetitions
Average peak torque/BW

Purpose: Examine flexion and extension torso strength

Background: Adequate torso muscle strength is important for the safe, efficient, and effective performance of virtually all demanding upper limb, lower limb, and whole-body tasks. Spinal muscle performance is critical for shielding the lower back's anatomical structures and connective tissues from potentially injurious forces. The lower back bones, discs, joints, nerves, and blood vessels are dependent on the health of the torso muscles as sources of dynamic joint stabilization and tissue stress-shields. Deficiencies in strength or reciprocal balance of the torso musculature may lead to injury to the lower back. Moreover, torso strength testing may reveal persistent torso muscle weakness after traumatic and overuse lower back injury which could lead to future injury.

Data and Results:

	Flexion (% BW)	Extension (% BW)	Flex/Ext (Ratio)
Top 10th %tile 3SFG	229.5	375.9	--
Top 25th %tile 3SFG	204.4	326.5	--
50th %tile 3SFG	180.5	287.5	--
Bottom 25th %tile 3SFG	157.7	248.0	--
Athlete*	280.0	650.0	
Triathletes	238.9 ± 40.9	415.0 ± 96.7	1.75 ± 0.34
Normative	--	--	1.3
3SFG	182.8 ± 34.7	294.6 ± 70.3	1.64 ± 0.37

***Flexion and Extension: Collegiate male wrestlers (Iwai, 2008). Extension/Flexion Ratio: Healthy adults (Smith, 1985).**

Summary: The average torso flexion strength was 35% lower than athlete values, 24% lower than the triathlete values, and 20% lower than the top 10th percentile of Operators. The average torso extension strength was 55% lower than the athlete, 29% lower than triathletes, and 22% lower than the top 10th percentile of Operators. Suboptimal extension/flexion ratio (<1.17 or >1.43) was identified in 73% of the Operators.

Musculoskeletal Flexibility
Shoulder Flexion and Extension Flexibility

Testing methodology:
Digital inclinometer
Average of 3 measurements (°)

Purpose: Examine shoulder flexion and extension flexibility

Background: Shoulder range of motion (ROM) is critical for maintenance of proper glenohumeral and shoulder girdle kinematics. A deficit in shoulder ROM will significantly impact overall performance during demanding overhead and upper extremity tasks and predispose the Operator to potentially traumatic and/or chronic pathologies.

Data and Results:

RIGHT

	Flexion (degrees)	Extension (degrees)
Top 10th %tile 3SFG	188	77
Top 25th %tile 3SFG	185	71
50th %tile 3SFG	183	65
Bottom 25th %tile 3SFG	180	56
Athlete*	168	81
Triathletes	177 ± 11	69 ± 9
Clinical Range	170-190	50-70
3SFG	183 ± 7	63 ± 11
5SFG	189 ± 7	81 ± 8

LEFT

	Flexion (degrees)	Extension (degrees)
Top 10th %tile 3SFG	187	75
Top 25th %tile 3SFG	185	69
50th %tile 3SFG	183	64
Bottom 25th %tile 3SFG	180	55
Athlete*	168	81
Triathletes	177 ± 11	71 ± 9
Clinical Range	170-190	50-70
3SFG	183 ± 7	62 ± 10
5SFG	189 ± 8	80 ± 8

***Non-dominant arm of professional baseball position players (Brown, 1988).**

Summary: The average shoulder flexion range of motion was consistent with the athlete, triathletes, and top 10th percentile of Operators. The average shoulder extension range of motion was 28% less than the athlete, consistent with the triathletes, and up to 21% less than the top 10th percentile of Operators. Suboptimal shoulder extension flexibility was identified in 41% of the Operators. Asymmetrical shoulder extension flexibility was identified in 27% of Operators.

Shoulder External and Internal Rotation and Posterior Shoulder Tightness Flexibility

Testing methodology:
Digital inclinometer
Average of 3 measurements (°)

Purpose: Examine shoulder external and internal rotation and Posterior Shoulder Tightness (PST) flexibility

Background: A balance between internal rotation (IR) and external rotation (ER) flexibility is desired to maintain appropriate glenohumeral joint kinematics and contributes to better physical performance during overhead activities. Posterior shoulder tightness (PST) may be the result of inflexible rotator cuff muscles and/or tightening of the posterior joint capsule which may lead to glenohumeral joint dysfunction and impingement syndromes.

Data and Results:

RIGHT

	External Rotation (degrees)	Internal Rotation (degrees)	PST (degrees)
Top 10th %tile 3SFG	111	69	124
Top 25th %tile 3SFG	105	61	119
50th %tile 3SFG	99	54	110
Bottom 25th %tile 3SFG	92	44	105
Athlete*	124	91	105
Triathletes	112 ± 7	54 ± 9	110 ± 7
Clinical Range	90-110	50-65	100-120
3SFG	99 ± 9	54 ± 11	111 ± 10
5SFG	109 ± 7	53 ± 6	99 ± 8

LEFT

	External Rotation (degrees)	Internal Rotation (degrees)	PST (degrees)
Top 10th %tile 3SFG	109	67	124
Top 25th %tile 3SFG	103	64	120
50th %tile 3SFG	96	55	110
Bottom 25th %tile 3SFG	90	51	105
Athlete*	124	91	105
Triathletes	109 ± 9	62 ± 10	111 ± 8
Clinical Range	90-110	50-65	100-120
3SFG	96 ± 10	57 ± 9	112 ± 9
5SFG	105 ± 7	52 ± 10	103 ± 8

***Internal and External Rotation: Non-dominant arm of professional baseball position players (Brown, 1988). Posterior Shoulder Tightness: Male collegiate swimmers (Oyama, 2006).**

Summary: The average external rotation range of motion was up to 27% less than the athletes, up to 12% less than the triathletes, and up to 12% less than the top 10th percentile of Operators. The average internal range of motion was up to 66% less than the athlete, consistent with the triathletes, and up to

26% less than the top 10th percentile of Operators. The average posterior shoulder tightness was consistent with the athlete, triathletes, and top 10th percentile of Operators. Suboptimal external rotation flexibility was identified in 53% of the Operators, internal rotation in 42% of the Operators, and posterior shoulder tightness in 27% of the Operators.

Hip Extension Flexibility

Testing methodology:
Saunders Digital Inclinometer (The Saunders Group, Chaska, MN)
Average of 3 measures (°)

Purpose: Examine passive hip extension flexibility

Background: Hip musculature flexibility is essential for the mobility and generation of force necessary to perform all physical tasks involving the lower extremity. Flexibility deficits at the hip will negatively impact overall performance, contributing to altered kinematics and increased stresses on distal joints leading to acute and chronic injuries that threaten the stability of the lower extremity.

Data and Results:

	Right Extension (degrees)	Left Extension (degrees)
Top 10th %tile 3SFG	32	32
Top 25th %tile 3SFG	28	26
50th %tile 3SFG	23	23
Bottom 25th %tile 3SFG	20	20
Triathletes	21 ± 8	21 ± 8
Normative	17	17
Clinical Range	20-40	20-40
3SFG	24 ± 5	24 ± 5
5SFG	25 ± 6	27 ± 6

***Healthy General Population, males 20-44 years old (Soucie, 2011).**

Summary: The average hip extension range of motion was up to 42% greater than athletes, up to 15% greater than triathletes, and approximately 26% less than the top 10th percentile of Operators. Hip extension was not suboptimal in any of the Operators. However, up to 18% of the Operators were below the clinical range for hip extension.

Knee Hamstring Flexibility

Testing methodology:
Saunders Digital Inclinometer (The Saunders Group, Chaska, MN)
Average of 3 measures (°)

Purpose: Examine active knee hamstring flexibility

Background: Maintenance of appropriate flexibility between the quadriceps and hamstring muscle groups contributes to maximal force generation across the available range of motion while also providing for the dynamic stabilization and stiffness necessary for joint protection during demanding tasks involving the lower extremity. Deficits in flexibility in one or both of these muscle groups may contribute to acute or chronic injuries affecting the proper functioning of the knee and jeopardizing overall joint stability.

Data and Results:

	Right Active Knee Extension (degrees)	Left Active Knee Extension (degrees)
Top 10th %tile 3SFG	6	10
Top 25th %tile 3SFG	13	15
50th %tile 3SFG	20	21
Bottom 25th %tile 3SFG	29	27
Athlete*	34	34
Triathletes	15 ± 11	14 ± 10
Clinical Range	0-10	0-10
3SFG	21 ± 10	21 ± 9
5SFG	16 ± 7	16 ± 9

Summary: For active knee extension, higher values are indicative of greater hamstring tightness/ inflexibility. The average active knee extension flexibility was 39% better than the athlete, but up to 51% and 246% worse than the triathletes and the top 10th percentile of Operators, respectively. The average active knee extension flexibility was suboptimal in up to 80% of the Operators, where suboptimal was defined as a greater than a 10% deficit of the triathlete average . In addition, up to 88% of the Operators where below the clinical range.

Ankle Dorsiflexion Flexibility

Testing methodology:
Saunders Digital Inclinometer (The Saunders Group, Chaska, MN)
Average of 3 measures (°)

Purpose: Examine active ankle dorsiflexion flexibility

Background: Adequate flexibility of the calf musculature contributes to proper mechanical functioning of the knee and ankle joints as well as the generation of forces necessary for tasks such as running and jumping. Deficits in calf musculature flexibility will have a negative impact on overall physical performance and may contribute to acute and/or chronic injuries involving the knee and ankle.

Data and Results:

	Right Dorsiflexion (degrees)	Left Dorsiflexion (degrees)
Top 10th %tile 3SFG	19	19
Top 25th %tile 3SFG	16	16
50th %tile 3SFG	13	14
Bottom 25th %tile 3SFG	12	12
Normative	12 ± 3	12 ± 3
Clinical Range	10-25	10-25
3SFG	14 ± 3	14 ± 3
5SFG	14 ± 4	13 ± 4

***Normative: General Healthy Population (Norkin & White, 2003).**

Summary: The average dorsiflexion flexibility was up to 19% greater than athletes and up to 26% less than the top 10^{th} percentile of Operators. The average ankle dorsiflexion flexibility was suboptimal in up to 16% of the Operators where suboptimal was defined as greater than a 10% deficit of the triathlete. However, the Operators were consistently within clinical range.

Posture

Testing methodology:
Modified 40cm combination square (Swanson)
Average of 3 measurements (cm)

Purpose: Examine forward shoulder girdle posture and pectoralis minor length

Background: Proper shoulder-neck-head postural alignment is important for the performance of rapid, co-ordinated head-on-neck and all upper limb movements. Appropriate postural alignment is critical for ensuring loads are evenly distributed over the upper body's joint surfaces and within the upper body's variety of tissues. Abnormal postural alignment may result in stress focus points within the joints and/or tissues which could lead to overuse injury or pain, and may cause nerves and blood vessels to become trapped as they run from the neck down the arm.

Data and Results:

FORWARD SHOULDER

	Right Forward Shoulder (cm)	Left Forward Shoulder (cm)
Top 10th %tile 3SFG	15	15
Top 25th %tile 3SFG	15	15
50th %tile 3SFG	16	16
Bottom 25th %tile 3SFG	18	18
Athlete*	15	15
3SFG	16 ± 2	16 ± 2

***Forward Shoulder: Male collegiate swimmers, dominant=right and non-dominant=left (Oyama, 2006).**

PECTORALIS MINOR

	Right Pectoralis Minor (cm)	Left Pectoralis Minor (cm)
Top 10th %tile 3SFG	5	5
Top 25th %tile 3SFG	6	6
50th %tile 3SFG	7	7
Bottom 25th %tile 3SFG	8	8
Normative	6 ± 1	6 ± 1
3SFG	7 ± 2	7 ± 1

***Pectoralis Minor: Healthy General Population, dominant=right and non-dominant=left (Lewis, 2007).**

Summary: For forward shoulder posture and pectoralis minor length, higher values are indicative of greater tightness/ inflexibility. Forward shoulder posture was consistent with normative and the top 10th percentile of Operators. Pectoralis minor posture was up to 17% worse than athletes and up to 40% worse than the top 10th percentile of Operators. In addition, up to 47% and 57% of Operators were suboptimal in forward should posture and pectoralis minor posture, respectively.

Balance
Dynamic Postural Stability

Testing methodology:
Kistler force plate
Average of 3 trials

Purpose: Examine dynamic postural stability through single-leg jump landing

Background: The dynamic postural stability index (DPSI) was used to quantify dynamic postural stability. The DPSI provides stability indices for the medial-lateral (MLSI), anterior-posterior (APSI), and vertical (VSI) direction as well as a composite score (DPSI). Lower scores indicate better dynamic postural stability. Accurate sensory information, as measured through single-leg jump landing testing, is essential to the performance of complex motor patterns, maintaining dynamic joint stability, and preventing injury. Deficits in this area may indicate a greater risk for knee, ankle, and lower limb injury

RIGHT

	MLSI	APSI	VSI	DPSI
Top 10th %tile 3SFG	0.0143	0.1228	0.2733	0.3040
Top 25th %tile 3SFG	0.0227	0.1275	0.3109	0.3407
50th %tile 3SFG	0.0290	0.1379	0.3433	0.3715
Bottom 25th %tile 3SFG	0.0325	0.1451	0.3586	0.3855
Athlete*	0.0300	0.1400	0.3300	0.3500
3SFG	0.0278 ± 0.0086	0.1380 ± 0.0116	0.3400 ± 0.0492	0.3686 ± 0.0482

LEFT

	MLSI	APSI	VSI	DPSI
Top 10th %tile 3SFG	0.0223	0.1205	0.2777	0.3062
Top 25th %tile 3SFG	0.0264	0.1298	0.3015	0.3315
50th %tile 3SFG	0.0289	0.1369	0.3255	0.3531
Bottom 25th %tile 3SFG	0.0346	0.1411	0.3682	0.3963
Athlete*	0.0300	0.1400	0.3300	0.3500
3SFG	0.0300 ± 0.0063	0.1347 ± 0.0097	0.3333 ± 0.0493	0.3613 ± 0.0473

***Recreational active males (Pederson, 2011).**

Summary: For dynamic postural stability, higher values are indicative of worse dynamic postural stability. The average MLSI, APSI, VSI, and DPSI scores for both legs were consistent with the athlete data. The average MLSI, APSI, VSI, and DPSI scores for both legs were up to 85%, 12%, 16%, and 16% worse than the top 10^{th} percentile of Operators, respectively. Suboptimal percentages of both legs across all dynamic postural stability variables ranged from 54 – 87%.

Sensory Organization Test

Testing methodology:
Neurocom
Average of 3 trials

Purpose: Examine postural stability

Background: Accurate sensory information, as measured through targeted sensory testing, is essential to the performance of complex motor patterns, maintaining dynamic joint stability, and preventing injury, especially in environments where the visual surround and base-of-support are frequently and quickly changing. Deficits in the ability to efficiently and effectively select and use different sources of sensory information may indicate a greater risk for lower back and lower limb injury.

Data and Results:
SENSORY ORGANIZATION TEST: COMPOSITE & COMPOSITE COMPONENT SCORES
The somatosensory, visual, and vestibular composite component scores indicate the ability to use input from the somatosensory, visual, and vestibular systems, respectively, to maintain balance. The Preference composite score is the degree to which the subject relies on visual information to maintain balance even when the information is incorrect.

	Composite	Somatosensory	Visual	Vestibular	Preference
Top 10th %tile 3SFG	87.90	100.00	96.00	86.00	104.90
Top 25th %tile 3SFG	84.00	99.00	94.00	83.00	100.25
50th %tile 3SFG	81.00	98.00	91.00	78.50	98.00
Bottom 25th %tile 3SFG	77.75	96.00	83.75	71.75	92.75
Athlete*	81.92	96.93	91.96	78.18	--
3SFG	80.68 ± 4.81	98.08 ± 2.32	88.68 ± 6.92	76.26 ± 9.10	96.26 ± 8.22

***Division I collegiate football players (McCaffrey, 2007).**

SENSORY ORGANIZATION TEST:
The sensory organization test progressively isolates each sensory system to objectively quantify an Operator's use of each sensory system for balance control. Conditions 1-3 assess the Operator's ability to use the somatosensory system to maintain balance control. Condition 4 assesses the Operator's ability to use the visual system to maintain balance control and conditions 5-6 assesses the Operator's ability to use the vestibular system to maintain balance control.

CONDITIONS 1-3

	Condition 1	Condition 2	Condition 3
Top 10th %tile 3SFG	96.64	94.97	95.27
Top 25th %tile 3SFG	96.00	94.00	93.31
50th %tile 3SFG	95.00	93.00	91.00
Bottom 25th %tile 3SFG	93.59	91.00	89.69
Athlete*	95.00	92.00	93.00
3SFG	94.43 ± 2.06	92.51 ± 2.24	91.39 ± 2.73

***Triathletes and competitive runners (Lepers, 1997).**

CONDITIONS 4-6

	Condition 4	Condition 5	Condition 6
Top 10th %tile 3SFG	91.70	81.20	79.27
Top 25th %tile 3SFG	89.42	77.17	76.42
50th %tile 3SFG	85.69	73.84	70.00
Bottom 25th %tile 3SFG	78.83	68.33	63.42
Athlete*	89.00	72.00	65.00
3SFG	83.93 ± 7.12	71.84 ± 8.26	67.29 ± 13.08

***Triathletes and competitive runners (Lepers, 1997).**

Summary: The average composite, somatosensory, visual, vestibular, and preference sensory composite scores were consistent with athletes. The average composite, somatosensory, visual, and preference sensory composite scores were consistent with the top 10th percentile of Operators and the vestibular composite score was approximately 12% less than the top 10th percentile of Operators. The average scores for all conditions (1-6) were consistent with athletes. The average scores for all conditions were consistent with the top 10th percentile of Operators, except for Condition 6 (vestibular) in which the average score was 16% less than the top 10th percentile of Operators. Approximately 28%, 18%, and 20% of the Operators were suboptimal for Conditions 4, 5, and 6 compared to the athlete, respectively, where suboptimal was defined as greater than a 10% deficit of the athlete average. None of the Operators were suboptimal in Conditions 1, 2, or 3.

Biomechanics
Scapular Kinematics: Humeral Elevation and Depression in the Scapular Plane

Testing methodology:
3D optical capture system (Vicon, Centennial, CO)

Purpose: Examine scapular kinematics with respect to the thorax

Background: Abnormal scapular kinematics, such as decreased scapular lateral rotation, is theorized to be related to shoulder injuries and pathologies such as subacromial impingement, as well as decreased athletic performance. Such altered scapular kinematics has been identified in athletes involved in overhead throwing or rock climbing, as well as patients with shoulder impingement injury. Overhead tasks such as reaching, loading of boats, climbing, and swimming are commonly performed by an Operator in military training and missions, and normal scapular kinematics are a critical component for Operators to perform such tasks while minimizing the risk of injury.

Data and Results:

RIGHT HUMERAL ELEVATION

	90 Degrees			120 Degrees		
	IR(+)/ER (-)	UR (+)/DR (-)	AT(-)/PT (+)	IR(+)/ER (-)	UR (+)/DR (-)	AT(-)/PT (+)
Top 10th %tile 3SFG	19.0	29.4	0.2	17.1	36.8	8.4
Top 25th %tile 3SFG	22.2	26.6	-2.8	22.7	34.0	4.4
50th %tile 3SFG	29.5	21.6	-7.5	32.9	28.0	-1.0
Bottom 25th %tile 3SFG	34.0	15.3	-12.5	40.5	23.1	-5.8
Normative	36.8 ± 10.9	18.0 ± 9.4	-4.2 ± 6.3	39.0 ± 12.8	24.9 ± 9.4	3.2 ± 9.7
Athlete*	43.5	-	-9.9	47.5	40.7	-8.1
3SFG	28.6 ± 6.8	21.8 ± 6.0	-7.7 ± 6.2	32.3 ± 10.9	29.1 ± 6.5	-1.1 ± 7.2

LEFT HUMERAL ELEVATION

	90 Degrees			120 Degrees		
	IR(+)/ER (-)	UR (+)/DR (-)	AT(-)/PT (+)	IR(+)/ER (-)	UR (+)/DR (-)	AT(-)/PT (+)
Top 10th %tile 3SFG	19.6	29.8	1.0	16.3	36.9	7.9
Top 25th %tile 3SFG	23.2	25.5	-2.8	23.3	32.5	4.5
50th %tile 3SFG	28.4	21.3	-6.5	29.4	28.2	-0.8
Bottom 25th %tile 3SFG	32.8	16.9	-10.8	38.3	23.4	-5.0
Normative	36.8 ± 10.9	18.0 ± 9.4	-4.2 ± 6.3	39.0 ± 12.8	24.9 ± 9.4	3.2 ± 9.7
Athlete*	43.5	-	-9.9	47.5	40.7	-8.1
3SFG	28.4 ± 6.4	21.3 ± 5.7	-6.8 ± 5.9	29.9 ± 10.0	28.6 ± 5.8	-0.4 ± 6.7

RIGHT HUMERAL DEPRESSION

	90 Degrees			120 Degrees		
	IR(+)/ER (-)	UR (+)/DR (-)	AT(-)/PT (+)	IR(+)/ER (-)	UR (+)/DR (-)	AT(-)/PT (+)
Top 10th %tile 3SFG	15.3	29.4	3.2	17.1	37.9	8.7
Top 25th %tile 3SFG	22.2	26.6	-0.4	22.7	34.5	5.7
50th %tile 3SFG	29.7	21.6	-5.6	32.9	28.9	-0.3
Bottom 25th %tile 3SFG	34.0	15.3	-9.1	40.5	22.9	-4.9
Normative	36.8 ± 10.9	18.0 ± 9.4	-4.2 ± 6.3	39.0 ± 12.8	24.9 ± 9.4	3.2 ± 9.7
Athlete*	43.5	-	-9.9	47.5	40.7	-8.1
3SFG	28.6 ± 6.8	22.0 ± 6.0	-5.9 ± 6.4	32.8 ± 12.1	29.1 ± 6.6	0.2 ± 7.1

LEFT HUMERAL DEPRESSION

	90 Degrees			120 Degrees		
	IR(+)/ER (-)	UR (+)/DR (-)	AT(-)/PT (+)	IR(+)/ER (-)	UR (+)/DR (-)	AT(-)/PT (+)
Top 10th %tile 3SFG	17.6	30.4	3.6	14.7	36.8	9.1
Top 25th %tile 3SFG	22.1	25.7	-0.9	23.1	32.3	6.0
50th %tile 3SFG	26.2	20.8	-4.3	29.4	27.8	1.6
Bottom 25th %tile 3SFG	30.8	17.9	-9.2	35.6	23.9	-3.3
Normative	36.8 ± 10.9	18.0 ± 9.4	-4.2 ± 6.3	39.0 ± 12.8	24.9 ± 9.4	3.2 ± 9.7
Athlete*	43.5	-	-9.9	47.5	40.7	-8.1
3SFG	26.6 ± 7.1	21.7 ± 5.6	-4.5 ± 6.1	29.7 ± 10.3	28.3 ± 5.6	1.0 ± 6.7

***Right Elevation & Depression: Male construction workers (Borstad, 2002). Normative Population: Healthy & physically active males (Myers, 2005)**

Summary

Humeral Elevation: The average scapular internal rotation at 90° humeral elevation was at least 22% less compared to the normal population, at least 34% less than the athletes and up to 51% greater than the top 10th percentile of Operators. For scapular upward rotation at 90° humeral elevation, an athlete model was not available for comparison. However, the average scapular upward rotation at 90° humeral elevation was up to 21% less than the normal population, and up to 29% less than the top 10th percentile of Operators. The average scapular tilt at 90° humeral elevation was up to 83% more anteriorly tilted compared to the normal population, up to 31% less anteriorly tilted compared to the athletes, and at least 780% more anteriorly tilted than the top 10th percentile of Operators. The average scapular internal rotation at 120° humeral elevation was at least 17% less compared to the normal population, 32% less than the athletes and up to 89% greater than the top 10th percentile of Operators. The average scapular upward rotation at 120° humeral elevation was up to 17% less than the normal population, 30% less than the athletes, and at least 21% less than the top 10th percentile of Operators. The average scapular tilt at 120° humeral elevation was up to 134% more anteriorly tilted compared to the normal population, up to 95% less anteriorly tilted compared to the athletes, and up to 113% less posteriorly tilted compared to the top 10th percentile of Operators.

Humeral Depression: The average scapular internal rotation at 90° humeral depression was at least 22% less compared to the normal population, at least 35% less than the athletes and up to 87% greater than the top 10th percentile of Operators. For scapular upward rotation at 90° humeral depression, an athlete model was not available for comparison. However, the average scapular upward rotation at 90° humeral depression was up to 22% less than the normal population, and up to 29% less than the top 10th percentile of Operators. The average scapular tilt at 90° humeral depression was up to 40% more anteriorly tilted compared to the normal population, up to 38% less anteriorly tilted compared to the athletes, and at least 225% more anteriorly tilted than the top 10th percentile of Operators. The average scapular internal rotation at 120° humeral depression was at least 16% less compared to the normal population, 29% less than the athletes and up to 102% greater than the top 10th percentile of Operators. The average scapular upward rotation at 120° humeral depression was up to 17% less than the normal population, 28% less than the athletes, and 23% less than the top 10th percentile of Operators. The average scapular tilt at 120° humeral depression was up to 94% less posteriorly tilted compared to the normal population, up to 119% more posteriorly tilted compared to the athletes, and up to 98% less posteriorly tilted compared to the top 10th percentile of Operators.

Hip Kinematics: Two-Legged Stop Jump

Testing methodology:
3D optical capture system (Vicon, Centennial, CO)

Purpose: Examine hip flexion at initial contact

Background:
The hip and surrounding musculature play an essential role in lower extremity dynamic stability. Landing with greater flexion at the hip will allow for more efficient use of the strong muscles of the hip and subsequent absorption of joint forces.

Data and Results:

RIGHT

	Hip Flexion @ Initial Contact (degrees)	Hip Abduction @ Initial Contact (degrees)
Top 10th %tile 3SFG	53	5 to -5
Top 25th %tile 3SFG	49	10 to -10
50th %tile 3SFG	41	15 to -15
Bottom 25th %tile 3SFG	37	20 to -20
Clinical Value	--	0.0
Triathletes	51.1 ± 13.2	-2.6 ± 3.5
3SFG	42.1 ± 8.7	-4.7 ± 3.2
5SFG	48.3 ± 9.6	-3.3 ± 3.4

LEFT

	Hip Flexion @ Initial Contact (degrees)	Hip Abduction @ Initial Contact (degrees)
Top 10th %tile 3SFG	54	5 to -5
Top 25th %tile 3SFG	49	10 to -10
50th %tile 3SFG	43	15 to -15
Bottom 25th %tile 3SFG	35	20 to -20
Clinical Value	--	0.0
Triathletes	54.4 ± 15.4	-2.0 ± 4.2
3SFG	42.9 ± 9.0	-4.6 ± 4.2
5SFG	50.71 ± 9.9	-2.8 ± 2.7

Summary: Average hip flexion angle at initial contact was up to 21% less than the triathletes and the top 10th percentile of Operators. For hip abduction, up to 51% of Operators were outside the clinical range, where suboptimal is defined as < -5° and > 5°.

Knee Kinematics: Two-Legged Stop Jump

Testing methodology:
3D optical capture system (Vicon, Centennial, CO)

Purpose: Examine maximum knee flexion and knee flexion at initial contact

Background:
Flexing the knee at landing and throughout dynamic tasks is essential to absorbing the dangerous landing forces experienced throughout the lower extremity. Inadequate flexion combined with a valgus knee angle can increase the strain on knee ligaments which can lead to tissue failure and injury.

Data and Results:

RIGHT

	Knee Flexion @ Initial Contact (degrees)			Knee Valgus @ Initial Contact (degrees)			Maximum Knee Flexion (degrees)		
Top 10th %tile 3SFG	34			5 to -5			109		
Top 25th %tile 3SFG	30			10 to -10			100		
50th %tile 3SFG	24			15 to -15			91		
Bottom 25th %tile 3SFG	19			20 to -20			83		
Clinical Value	--			0.0			--		
Triathletes	29.9	±	8.7	5.6	±	3.8	82.4	±	11.9
3SFG	24.5	±	6.8	6.6	±	5.2	92.1	±	13.4
5SFG	28.7	±	8.1	4.2	±	8.9	98.6	±	12.2

LEFT

	Knee Flexion @ Initial Contact (degrees)			Knee Valgus @ Initial Contact (degrees)			Maximum Knee Flexion (degrees)		
Top 10th %tile 3SFG	35			5 to -5			106		
Top 25th %tile 3SFG	29			10 to -10			99		
50th %tile 3SFG	25			15 to -15			86		
Bottom 25th %tile 3SFG	20			20 to -20			79		
Clinical Value	--			0.0			--		
Triathletes	34.8	±	9.5	6.2	±	9.1	84.8	±	8.3
3SFG	24.7	±	8.6	5.6	±	6.0	88.4	±	14.4
5SFG	31.6	±	8.2	4.9	±	13.0	96.6	±	13.4

Summary: Average knee flexion angle at initial contact was up to 28% and 29% less compared to the triathletes and top 10th percentile of Operators, respectively. Average maximum knee flexion was up to 11% greater compared to triathletes and up to 17% less than the top 10th percentile of Operators. For knee valgus at initial contact, up to 68% of Operators were outside the clinical range, where suboptimal is defined as < -5° and > 5°.

Ground Reaction Forces: Two-Legged Stop Jump

Testing methodology:
3D optical capture system (Vicon, Centennial, CO)

Purpose: Examine peak vertical ground reaction forces

Background: Vertical ground reaction forces directly correlate with high joint forces. Individuals who are able to decrease landing forces through modified landing strategies should be able to mitigate these forces and reduce their risk of injury.

Data and Results:

RIGHT

	Peak Vertical GRF (%BW)
Top 10th %tile 3SFG	147
Top 25th %tile 3SFG	171
50th %tile 3SFG	212
Bottom 25th %tile 3SFG	254
Triathletes	210.8 ± 48.1
3SFG	228.1 ± 85.4
5SFG	198.4 ± 55.6

LEFT

	Peak Vertical GRF (%BW)
Top 10th %tile 3SFG	147
Top 25th %tile 3SFG	165
50th %tile 3SFG	192
Bottom 25th %tile 3SFG	244
Triathletes	224.3 ± 63.2
3SFG	205.7 ± 56.3
5SFG	188.6 ± 55.7

Summary: Average peak vertical ground reaction force was consistent with the triathletes and up to 53% greater than the top 10^{th} percentile of Operators.

Hip Kinematics: Single-Legged Drop Landing

Testing methodology:
3D optical capture system (Vicon, Centennial, CO)

Purpose: Examine hip flexion at initial contact

Background:
The hip and surrounding musculature play an essential role in lower extremity dynamic stability. Landing with greater flexion at the hip will allow for more efficient use of the strong muscles of the hip and subsequent absorption of joint forces.

Data and Results:

RIGHT

	Hip Flexion @ Initial Contact (degrees)	Hip Abduction @ Initial Contact (degrees)
Top 10th %tile 3SFG	26	5 to -5
Top 25th %tile 3SFG	22	10 to -10
50th %tile 3SFG	18	15 to -15
Bottom 25th %tile 3SFG	13	20 to -20
Clinical Value	--	0.0
3SFG	17.70 ± 6.06	-10.58 ± 4.33

LEFT

	Hip Flexion @ Initial Contact (degrees)	Hip Abduction @ Initial Contact (degrees)
Top 10th %tile 3SFG	25	5 to -5
Top 25th %tile 3SFG	22	10 to -10
50th %tile 3SFG	17	15 to -15
Bottom 25th %tile 3SFG	14	20 to -20
Clinical Value	--	0.0
3SFG	17.55 ± 6.20	-11.42 ± 4.36

Summary: Average hip flexion angle at initial contact was up to 30% less compared to the top 10th percentile of Operators. Average hip abduction at initial contact was outside the clinical range in up to 96% of the Operators, where suboptimal is defined as < -5° and > 5°.

Knee Kinematics: Single-Legged Drop Landing

Testing methodology:
3D optical capture system (Vicon, Centennial, CO)

Purpose: Examine maximum knee flexion and knee flexion at initial contact

Background:
Flexing the knee at landing and throughout dynamic tasks is essential to absorbing the dangerous landing forces experienced throughout the lower extremity. Inadequate flexion combined with a valgus knee angle can increase the strain on knee ligaments which can lead to tissue failure and injury.

Data and Results:

RIGHT

	Knee Flexion @ Initial Contact (degrees)	Knee Valgus @ Initial Contact (degrees)	Maximum Knee Flexion (degrees)
Top 10th %tile 3SFG	19	5 to -5	69
Top 25th %tile 3SFG	17	10 to -10	62
50th %tile 3SFG	12	15 to -15	58
Bottom 25th %tile 3SFG	8	20 to -20	52
Clinical Value	--	0.0	--
3SFG	12.15 ± 5.29	1.08 ± 3.32	57.81 ± 8.49

LEFT

	Knee Flexion @ Initial Contact (degrees)	Knee Valgus @ Initial Contact (degrees)	Maximum Knee Flexion (degrees)
Top 10th %tile 3SFG	18	5 to -5	66
Top 25th %tile 3SFG	17	10 to -10	62
50th %tile 3SFG	13	15 to -15	56
Bottom 25th %tile 3SFG	8	20 to -20	50
Clinical Value	--	0.0	--
3SFG	12.22 ± 6.03	-0.47 ± 4.58	56.36 ± 9.52

Summary: Average knee flexion angle at initial contact was up to 33% less compared to the top 10th percentile of Operators. Average maximum knee flexion was up to 17% less the top 10th percentile of Operators. For average knee valgus at initial contact, up to 18% of Operators were outside the clinical range, where suboptimal is defined as < -5° and > 5°.

Ground Reaction Forces: Single-Legged Drop Landing

Testing methodology:
3D optical capture system (Vicon, Centennial, CO)

Purpose: Examine peak vertical ground reaction forces

Background: Vertical ground reaction forces directly correlate with high joint forces. Individuals who are able to decrease landing forces through modified landing strategies should be able to mitigate these forces and reduce their risk of injury.

Data and Results:

RIGHT

	Peak Vertical GRF (%BW)
Top 10th %tile 3SFG	487
Top 25th %tile 3SFG	519
50th %tile 3SFG	595
Bottom 25th %tile 3SFG	664
3SFG	609 ± 111

LEFT

	Peak Vertical GRF (%BW)
Top 10th %tile 3SFG	431
Top 25th %tile 3SFG	487
50th %tile 3SFG	555
Bottom 25th %tile 3SFG	612
3SFG	563.71 ± 104.80

Summary: Average peak vertical ground reaction force was up to 28% greater than the top 10th percentile of Operators.

Physiology
Body Composition

Testing methodology:
BOD POD body composition tracking system

Purpose: Examine body composition (fat mass/fat-free mass)

Background: Physical performance can be improved by increasing the lean tissue mass (muscle) within the body, ultimately increasing strength and reducing the effects of fatigue due to excessive body mass and body fat. Similarly, too little body fat has also been shown to negatively affect athletic performance as low essential fat stores interfere with the normal physiological processes of the body, increase the risk of injury, and prolong injury recovery. Low body fat stores may decrease the available fuel to sustain prolonged training and combat missions. Additionally, the varying terrains and environmental conditions further support the importance of optimal body composition distribution. From a long-term health prospective, less body fat will decrease the risk of hypokinetic diseases (i.e. cardiovascular disease, diabetes, hypertension, hypercholesterolemia).

Data and Results:

	Body Fat (%)	Height (inches)	Weight (pounds)
Top 10th %tile 3SFG	9.32	--	--
Top 25th %tile 3SFG	12.40	--	--
50th %tile 3SFG	15.80	--	--
Bottom 25th %tile 3SFG	19.50	--	--
Athlete*	15.42	--	--
Triathletes	12.31 ± 4.37	--	--
3SFG	15.90 ± 5.22	70.76 ± 2.08	186.87 ± 21.18
5SFG	16.31 ± 6.23	69.75 ± 3.64	175.11 ± 25.79

***NMRL Database of Professional Football Players**

Summary: The average percent body fat was consistent with the athletes, 29% higher than the triathletes, and 29% higher than the top 10th percentile of Operators. Based on data from our previous studies with Special Forces Operators, there is a marked increase in musculoskeletal injuries in subjects starting at 15% body fat. Overall, approximately 57% of Operators have body fat percentages that exceed this threshold.

Anaerobic Power/Anaerobic Capacity

Testing methodology:
Velotron cycling ergometer (RacerMate, Inc., Seattle, WA)
Measuring range: 5 to 2000 watts
Accuracy: +/- 1.5%
Repeatability: +/- 0.2 % or better

Purpose: Examine anaerobic power/anaerobic capacity

Background: The development of lower extremity overuse injuries has been associated with low levels of physical fitness. Suboptimal levels of anaerobic power, along with other diminished physiological characteristics, as a result of non-scientifically structured training have been directly related to an increased risk of injury and impaired performance. Anaerobic power/anaerobic capacity is critical when high intensity, high stress bouts are followed by the need for tactical performance (gun firing).

Data and Results:

	Anaerobic Power (W/kg)			Anaerobic Capacity (W/kg)		
Top 10th %tile 3SFG	15.98			9.40		
Top 25th %tile 3SFG	15.03			9.03		
50th %tile 3SFG	13.90			8.70		
Bottom 25th %tile 3SFG	12.90			8.00		
Athlete*	16.86			10.45		
Triathletes	13.75	±	1.05	9.25	±	0.70
3SFG	13.93	±	1.48	8.51	±	0.94
5SFG	13.47	±	2.16	8.21	±	0.93

***NMRL Database of Professional Ice Hockey Players**

Summary: Anaerobic power was approximately 17% less than athletes and consistent with the triathletes and the top 10th percentile of Operators. Anaerobic capacity was approximately 18% less than athletes, consistent with the triathletes, and 11% less than the top 10th percentile of Operators.

Aerobic Capacity

Testing methodology:
Viasys Oxycon Mobile portable ergospirometry system
Arkray LactatePro blood lactate test meter

Purpose:
Examine aerobic capacity (VO_{2max}/lactate threshold)

Background: The development of overuse injuries has been associated with low levels of physical fitness. A significant relationship has been reported between less aerobically fit Operators and increased injuries as compared to Operators who are more fit. Suboptimal levels of maximal oxygen consumption and lactate threshold have been directly related to an increased risk of injury and impaired performance as premature fatigue results. Improvements in maximal oxygen consumption and lactate threshold with training will permit workout levels at higher intensities for longer durations without the accumulation of blood lactate to impair performance, while making the Operator more fatigue resistant.

Data and Results:

VO2

	VO2 max (ml/kg/min)	VO2 @ LT (ml/kg/min)	VO2 @ LT (% VO2 max)
Top 10th %tile 3SFG	55.88	46.75	92.73
Top 25th %tile 3SFG	52.70	42.53	85.93
50th %tile 3SFG	48.70	36.85	74.75
Bottom 25th %tile 3SFG	46.28	33.00	69.13
Triathletes	69.76 ± 7.29	58.20 ± 7.30	83.66 ± 8.52
3SFG	48.96 ± 4.62	38.10 ± 5.95	77.65 ± 10.04
5SFG	50.94 ± 5.62	38.33 ± 3.17	73.45 ± 12.64

HEARTRATE

	HR max (beats/min)	HR @ LT (beats/min)	HR @ LT (% HR max)
Top 10th %tile 3SFG	196	174	94.34
Top 25th %tile 3SFG	193	170	92.03
50th %tile 3SFG	187	160	85.45
Bottom 25th %tile 3SFG	180	149	80.55
Triathletes	182.73 ± 11.28	167.20 ± 12.18	91.51 ± 3.94
3SFG	186.14 ± 8.73	159.46 ± 12.96	86.00 ± 6.64
5SFG	191.23 ± 8.71	166.00 ± 9.30	84.87 ± 6.68

Summary: The average VO_{2max} was approximately 30% less than the triathletes and 12% less than the top 10^{th} percentile of Operators. The average lactate threshold (% VO_{2max}) was consistent with triathletes and 18% less than the top 10^{th} percentile of Operators. Aerobic capacity and lactate threshold were suboptimal in 90% and 70% of the Operators, respectively (VO_{2max} < 55 ml/kg/min, lactate threshold less than 85% VO_{2max}).

Personnel

COL Russ Kotwal, the USASOC Principal Investigator, was reassigned and removed from the project as the Principal Investigator. COL Pete Benson, Command Surgeon- USASOC, was added as the Principal Investigator. Meetings were held with LTC Mike Henry, Command Surgeon- USASFC and LTC Mike Radnothy- Flight Surgeon- 3SFG to introduce the research project and engage as Associate Investigators.

Human Subject Protections
Human subject protections is maintained by review boards from the University of Pittsburgh, Womack Army Medical Center, and higher level review performed by Clinical Investigation Regulatory Office and Office of Research Protections, Human Research Protection Office.

University of Pittsburgh
Original submission of human subject protections documents to the University of Pittsburgh received approval on March 8, 2011. Continuing review (year 2 research) submitted January 4, 2012 and approved January 25, 2012 with an expiration of January 24, 2013 (approval letter attached). Continuing review (year 3 research) submitted October 16, 2012 and approved with an expiration date of November 5, 2013 (approval letter attached).

Womack Army Medical Center
Original submission of human subject protections documents to Womack Army Medical Center received approval on August 19, 2011.

An amendment (IRBNet 377905-2) was submitted June 21, 2012 and approved July 9, 2012.
- COL Russ Kotwal was removed as the USASOC Principal Investigator and replaced with COL Pete Benson, MD- USASOC Command Surgeon. COL Kotwal was added as a collaborator on the study.
- Under protocol section 12.0 HIPAA AUTHORIZATION, part VI, it was checked to indicate that PHI will be sent outside WAMC. This was not correct and no PHI has or will be sent outside of WAMC. Rather, the three research assistants listed in the original approved protocol will be viewing AHLTA through hard wired DoD computers linked to the WAMC network from the USASOC research facility. Of note, this will be exactly the same way USASOC healthcare providers access AHLTA for patient care issues. The three research assistants are contract employees who were hired specifically for this research project. The specific PHI they will access as listed in Figure 1, protocol section 8.0 Data Analysis, will never leave the covered entity. Of note, though study enrollment has occurred the research assistants have not yet accessed any covered entity information via AHLTA because the networking of the computers and CAC card processing is not yet complete.

Continuing review was submitted April 30, 2012 and approved June 8, 2012.

An amendment (IRBNet 377905-3) was submitted on September 9, 2012 and approved September 25, 2012.
- Added the Armed Forces Health Surveillance Center as a secondary source to obtain prospective injury data
- Added secondary plane of testing for shoulder strength on the Biodex Isokinetic Dynamometer

Reportable Outcomes

Abstracts
Not applicable

Manuscripts
Not applicable

Grant Submissions
Not applicable

Conclusions
Not applicable

References
Not applicable

Appendices
Attached

DEPARTMENT OF THE ARMY
Womack Army Medical Center
Fort Bragg, North Carolina 28310

REPLY TO
ATTENTION OF

MCXC-DME-RES

8 June 2012

MEMORANDUM FOR LTC (P) Russ Kotwal, Deputy DCS Surgeon, United States Army Special Operations Command (AOMD), 2929 Desert Storm Drive (Stop A), Fort Bragg, NC 28310

SUBJECT: Approval of Continuing Review WAMC #110504 [IRBNet #377905-1] "USASOC Injury Prevention and Performance Optimization Research Initiative."

1. Your Continuing Review Report, dated 30 April 2012, was granted Full Board approval on 8 June 2012. Initial study approval was granted by the Full Convened IRB on 8 July 2011 as Greater Than Minimal Risk (GTMR). The risk level remains the same. This study is active and remains open to enrollment.

2. The current approved documents for your study are attached to this IRBNet package. These documents include:

  a. Protocol, v. 17 January 2012

  b. ICF/HIPAA document, v. 22 November 2011, stamped date of 8 June 2012

Please be sure to update your records with these documents and begin using this newly stamped ICF/HIPAA document. Discard all old ICF/HIPAA documents.

3. Current approval for this study expires on **7 June 2013**. The next continuing review for this protocol is due on **7 April 2013**.

4. If you have any questions, the POC is Ms. Cheri Portee at (910) 907-8964 or you may email the IRB Administrative team at wamc.irbadmin@amedd.army.mil.

Carolyn H Smoak

CAROLYN H. SMOAK
DVM, PharmD
Acting IRB Chair

USASOC DATE 20 June 2012

MEMORANDUM FOR Chair, Institutional Review Board, Womack Army Medical Center, Fort Bragg, NC 28310

SUBJECT: Amendment Request for Change in Protocol

1. PROTOCOL TITLE: USASOC Injury Prevention and Performance Optimization Research Initiative

WAMC Work Unit #: Womack Protocol Number #110504, IRBNet Protocol Number 377905-1

PRINCIPAL INVESTIGATOR: COL Russ Kotwal

DEPARTMENT/SERVICE: USASOC

TELEPHONE NO.: 910-396-1581

2. THE PROGRESS IN APPROVED EXPERIMENTS, TO INCLUDE PAST PRODUCTIVITY: To date, 34 subjects have been enrolled and completed laboratory testing for biomechanical, musculoskeletal, and physiological characteristics.

3. EXPLANATION OF THE PLANNED EXPERIMENTS TO BE UNDERTAKEN OR MODIFICATIONS OF THE STUDY:

3.1 Under protocol section 12.0 HIPAA AUTHORIZATION, part VI, it is presently checked to indicate that PHI will be sent outside WAMC. This is not correct and no PHI has or will be sent outside of WAMC. Rather, the 3 research assistants listed in the original approved protocol will be viewing AHLTA through hard wired DoD computers linked to the WAMC network from the USASOC research facility. Of note, this will be exactly the same way USASOC healthcare providers access AHLTA for patient care issues. These 3 research assistants are contract employees who were hired specifically for this research project. The specific PHI they will access as listed in Figure 1, protocol section 8.0 Data Analysis, will never leave the covered entity. Of note, though study enrollment has occurred, the research assistants have not yet accessed any covered entity information via AHLTA because the networking the computers and CAC card processing is not yet complete.

3.2 Addition of COL Pete Benson, MD as the principal investigator on the project to replace COL Russ Kotwal, MD. COL Kotwal will PCS from Fort Bragg and will remain a collaborator on the study.

Please red-tracked changes to the protocol.

4. COMMENTS ON WHETHER THE MODIFICATIONS WILL INCREASE RISKS TO PARTICIPANTS ENROLLED IN THE STUDY: These medications will not increase risk. Furthermore, though PHI was never intended to nor have they left Fort Bragg, these modifications serve to further clarify how risks are minimized by clearly specifying that they will not leave Fort Bragg.

5. SUMMARY OF PAST SPENDING AND JUSTIFICATION FOR ADDITIONAL FUNDING: No budgetary changes are requested.

6. NUMBER OF SUBJECTS (OR ANIMALS) ENROLLED TO DATE: 34

7. JUSTIFICATION FOR ADDITIONAL SUBJECTS (OR ANIMALS) AND METHOD OF RECRUITMENT FOR SUBJECTS: No changes to enrollment numbers or recruitment strategy is requested.

Encl.

1. Red-tracked changes to protocol.
2. Current informed consent-HIPAA Authorization document. Of note, no changes to this document are requested, i.e., HIPAA Authorization does NOT request permission from subject to send PHI outside of the covered entity.

For Human Use Study – Include 1) an electronic copy of the proposed consent form with all changes highlighted; and 2) a copy of most recent approved consent form if the subject accrual is ongoing.

COL Russ Kotwal, MD, MPH, FAAFP
(Signature, Principal Investigator)
PI's SIGNATURE & TYPED SIGNATURE BLOCK

IRB approval date: ________________
Full: ________________
Expedited: ________________

____
(Signature, Chair or Vice-Chair, IRB

DEPARTMENT OF THE ARMY
Womack Army Medical Center
Fort Bragg, North Carolina 28310

REPLY TO
ATTENTION OF

MCXC-DME-RES 9 July 2012

MEMORANDUM FOR COL Pete Benson, MD, DCS Surgeon, USASOC (AOMD), Womack Army Medical Center; Fort Bragg, NC 28310

SUBJECT: Approval of Amendment Request for IRBNet #377905-1, "USASOC Injury Prevention and Performance Optimization Research Initiative."

1. The Institutional Review Board (IRB) approved your addendum dated 20 June 2012 through an Expedited procedure. This study was originally approved by a Full Convened IRB as Greater Than Minimal Risk on 8 July 2011. It is currently open for recruitment and enrollment.

2. Per your amendment request, the Principal Investigator has been changed **FROM** COL Russ Kotwal **TO** COL Pete Benson and this change is indicated in the protocol and ICF/HIPAA documents. COL Kotwal will remain on the study as a Collaborator.

In addition, a correction to the protocol, section 12.0 HIPAA AUTHORIZATION, part VI, has been made. The correction clarifies that **NO PHI** will be sent outside of Womack Army Medical Center (WAMC). Further clarification has been made, stating no there has never been PHI sent outside of WAMC.

These changes do not affect the informed consent or recruitment process. However, administrative changes have been made. The protocol and ICF/HIPAA document are revised, versions 6 July 2012. Please destroy all old ICF/HIPAA documents and begin using the stamped approved date 9 July 2012 now. Please note that the expiration date remains the same (7 June 2013).

3. If you have any questions, the POC is Ms. Cheri Portee at (910) 907-8964 or you may email the IRB Administrative team at wamc.irbadmin@amedd.army.mil.

Diane M. Allen
DIANE M. ALLEN
MSN, ANP, BC, CLS
Chair, Institutional Review Board

USASOC DATE 09 SEPT 2012

MEMORANDUM FOR Chair, Institutional Review Board, Womack Army Medical Center, Fort Bragg, NC 28310

SUBJECT: Amendment Request for Change in Protocol

1. PROTOCOL TITLE: USASOC Injury Prevention and Performance Optimization Research Initiative

WAMC Work Unit #: Womack Protocol Number #110504, IRBNet Protocol Number 377905-1

PRINCIPAL INVESTIGATOR: COL Pete Benson

DEPARTMENT/SERVICE: USASOC

TELEPHONE NO.: (910) 432-5408

2. THE PROGRESS IN APPROVED EXPERIMENTS, TO INCLUDE PAST PRODUCTIVITY: To date, 49 subjects have been enrolled and completed laboratory testing for biomechanical, musculoskeletal, and physiological characteristics.

3. EXPLANATION OF THE PLANNED EXPERIMENTS TO BE UNDERTAKEN OR MODIFICATIONS OF THE STUDY:

3.1 Clarification of data provided by the Armed Forces Health Surveillance System. Will supplement the data collected with AHLTA.

3.2 Addition shoulder strength measures to testing battery.

4. COMMENTS ON WHETHER THE MODIFICATIONS WILL INCREASE RISKS TO PARTICIPANTS ENROLLED IN THE STUDY: The modifications will not increase risk to participants enrolled in the study. Data obtained from the AFHSC is a supplemental mechanism to obtain in jury data for which the subject has already consented. Additionally, shoulder strength data are currently being collected, this modification includes capturing data in a different plane.

5. SUMMARY OF PAST SPENDING AND JUSTIFICATION FOR ADDITIONAL FUNDING: No budgetary changes are requested.

6. NUMBER OF SUBJECTS (OR ANIMALS) ENROLLED TO DATE: 49

7. JUSTIFICATION FOR ADDITIONAL SUBJECTS (OR ANIMALS) AND METHOD

OF RECRUITMENT FOR SUBJECTS: No changes to enrollment numbers or recruitment strategy is requested.

Encl.

1. Red-tracked changes to protocol.
2. Current informed consent-HIPAA Authorization document. Of note, no changes to this document are requested as procedures are currently included.

For Human Use Study – Include 1) an electronic copy of the proposed consent form with all changes highlighted; and 2) a copy of most recent approved consent form if the subject accrual is ongoing.

COL Pete Benson, MD
(Signature, Principal Investigator)
PI's SIGNATURE & TYPED SIGNATURE BLOCK

IRB approval date: ________________
Full: ________________
Expedited: ________________

____
(Signature, Chair or Vice-Chair, IRB

DEPARTMENT OF THE ARMY
Womack Army Medical Center
Fort Bragg, North Carolina 28310

REPLY TO
ATTENTION OF:

MCXC-DME-RES 25 September 2012

MEMORANDUM FOR: Pete Benson, Womack Army Medical Center, 2817 Reilly Road, Fort Bragg, NC 28310-7301

SUBJECT: [377905-3] USASOC Injury Prevention and Performance Optimization Research Initiative

1. The amendment you submitted dated 9 September 2012 was approved on 25 September 2012 by expedited review.

2. The approved changes include:

a. Clarification of the AFHSC supplemental mechanism to obtain injury data for which the subject has already consented.

b. Modification to include capturing data in a different plane on shoulder strength.

3. Changes have been made to the protocol and accepted. The current protocol is published with this package. No changes have been made to the ICF/HIPAA document.

4. The POC is Linda Jenkins at (910) 907-6277 or linda.j.jenkins@us.army.mil. Please include your project title and reference number in all correspondence with this committee.

This document has been electronically signed in accordance with all applicable regulations, and a copy is retained within our records.

University of Pittsburgh
Institutional Review Board

3500 Fifth Avenue
Pittsburgh, PA 15213
(412) 383-1480
(412) 383-1508 (fax)
http://www.irb.pitt.edu

Memorandum

To: John Abt, PhD

From: Margaret Hsieh, MD, Vice Chair

Date: 1/31/2012

IRB#: REN12010018 / PRO10120222

Subject: USASOC Injury Prevention/Performance Optimization Musculoskeletal Screening Initiative-Phases 1 and 2

The Renewal for the above referenced research study was reviewed and approved by the Institutional Review Board, Committee H, which met on 1/25/2012.

The risk level designation is Greater Than Minimal Risk

Approval Date:	1/25/2012
Expiration Date:	1/24/2013

Please note that it is the investigator's responsibility to report to the IRB any unanticipated problems involving risks to subjects or others [see 45 CFR 46.103(b)(5) and 21 CFR 56.108(b)]. Refer to the IRB Policy and Procedure Manual regarding the reporting requirements for unanticipated problems which include, but are not limited to, adverse events. If you have any questions about this process, please contact the Adverse Events Coordinator at 412-383-1480.

The protocol and consent forms, along with a brief progress report must be resubmitted at least **one month** prior to the renewal date noted above as required by FWA00006790 (University of Pittsburgh), FWA00006735 (University of Pittsburgh Medical Center), FWA00000600 (Children's Hospital of Pittsburgh), FWA00003567 (Magee-Womens Health Corporation), FWA00003338 (University of Pittsburgh Medical Center Cancer Institute).

Please be advised that your research study may be audited periodically by the University of Pittsburgh Research Conduct and Compliance Office.

University of Pittsburgh
Institutional Review Board

3500 Fifth Avenue
Pittsburgh, PA 15213
(412) 383-1480
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http://www.irb.pitt.edu

Memorandum

To: John Abt, PhD, ATC
From: Ron Shapiro, MD, Vice Chair
Date: 11/13/2012
IRB#: REN12100123 / PRO10120222
Subject: USASOC Injury Prevention/Performance Optimization Musculoskeletal Screening Initiative-Phases 1 and 2

The Renewal for the above referenced research study was reviewed and approved by the Institutional Review Board, Committee A, which met on 11/6/2012.

Please note the following information:

The risk level designation is Greater Than Minimal.

Approval Date: 11/6/2012
Expiration Date: 11/5/2013

Please note that it is the investigator's responsibility to report to the IRB any unanticipated problems involving risks to subjects or others [see 45 CFR 46.103(b)(5) and 21 CFR 56.108(b)]. Refer to the IRB Policy and Procedure Manual regarding the reporting requirements for unanticipated problems which include, but are not limited to, adverse events. If you have any questions about this process, please contact the Adverse Events Coordinator at 412-383-1480.

The protocol and consent forms, along with a brief progress report must be resubmitted at least **one month** prior to the renewal date noted above as required by FWA00006790 (University of Pittsburgh), FWA00006735 (University of Pittsburgh Medical Center), FWA00000600 (Children's Hospital of Pittsburgh), FWA00003567 (Magee-Womens Health Corporation), FWA00003338 (University of Pittsburgh Medical Center Cancer Institute).

Please be advised that your research study may be audited periodically by the University of Pittsburgh Research Conduct and Compliance Office.